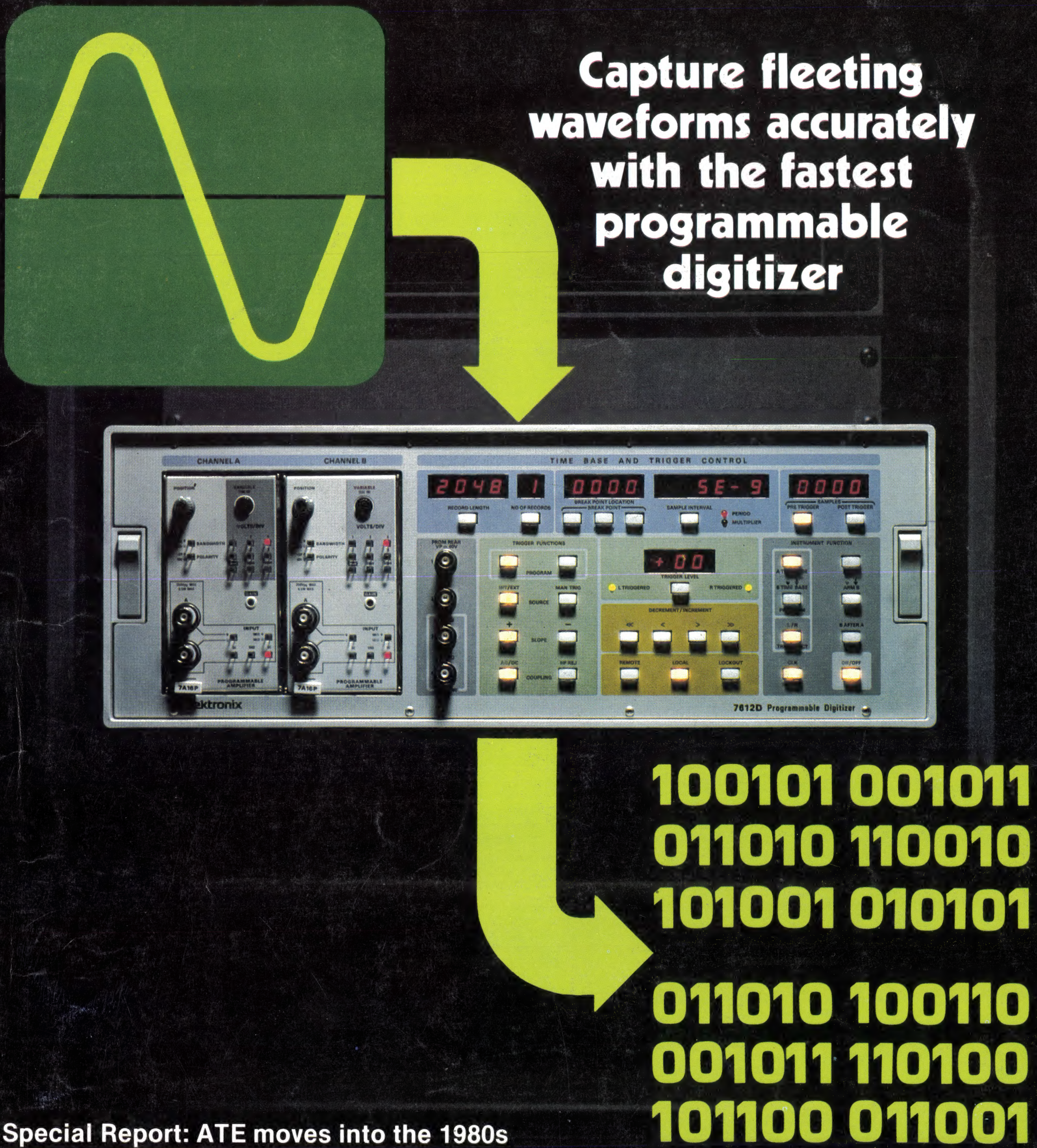
Electronic Design

International Edition

VOL. 28 NO. 3

FOR ENGINEERS AND ENGINEERING MANAGERS — WORLDWIDE

FEB. 1, 1980



Capture fleeting waveforms accurately with the fastest programmable digitizer
CHANNEL A
CHANNEL B
TIME BASE AND TRIGGER CONTROL
2048
1
0000
SE-9
0000
+00
Tektronix
7612D Programmable Digitizer
100101 001011
011010 110010
101001 010101
011010 100110
001011 110100
101100 011001

Special Report: ATE moves into the 1980s

Combating the problems of analog-circuit testing

Designing switching supplies above 100 kHz (Part 2)

Put single-chipper's eight operating modes to work

When the Doctor heard we were famous for our custom work, he wanted to order a bride for Frankie.

Sorry Doc. It's custom MOS/LSI.

Match-making is a little out of our line. But we *have* come up with quite a few original creations. For custom MOS/LSI circuits.

Over the past couple of years, in fact, we've designed and built well over 100 different custom LSI circuits for America's leading companies. In every field, from data communications and computer peripherals to business machines, avionics and entertainment.

A leader in creating new MOS/LSI technology, we pioneered high performance n-channel silicon gate devices with our patented COPLAMOS® technology. We also introduced another technological breakthrough that's fast becoming a buzzword in the industry. It's called CLASP® which stands for COPLAMOS Last Stage Programmable.

With CLASP we can complete all of the wafer processing steps including metalization before defining the bit pattern for read-only-memories.

Standard Microsystems provides a total capability. We design, develop, process, assemble and test state-of-the-art MOS/LSI circuits. That means we can design from scratch, or enter the custom cycle at any point you want. And assisting us at every step is the latest computer-aided design and diagnostic equipment.

So, whenever you need custom LSI, come to Standard Microsystems for your own special creation.

STANDARD MICROSYSTEMS CORPORATION

35 Marcus Blvd., Hauppauge, N.Y. 11787
(516) 273-3100 TWX-510-227-8898

We keep ahead of our competition so you can keep ahead of yours.

CIRCLE NUMBER 2

SURPRISE!

HP Introduces the World's First Digital Bar Code Wand.

Anyone now using a keyboard or push buttons for data entry could benefit from using bar codes.

Depending on the number of characters being entered, bar code scanning has been shown to be from two to four times faster than key entry.

HP's new HEDS-3000 Digital Bar Code Wand can scan black-and-white bar codes and convert the codes to microprocessor-recognizable digital output. Fully specified and guaranteed, the Wand contains a push-to-read switch which conserves power. It is well suited to portable systems as well as those with line power. The Wand is housed in a rugged, stylized, molded plastic case with attached cord and connector. Of even further interest to OEM's, the HEDS-3000 can be manufactured in custom colors with desired logos.

In quantities 1-99, the Wand is priced at \$99.50* each.

For more information or immediate off-the-shelf delivery, contact your nearest HP Components franchised distributor. In the U.S. contact Hall-Mark, Hamilton/Avent, Pioneer Standard, Schweber, Wilshire or the Wyle Distribution Group (Liberty/Elmar). In Canada, call Hamilton/Avnet or Zentronics, Ltd.

HEWLETT
PACKARD

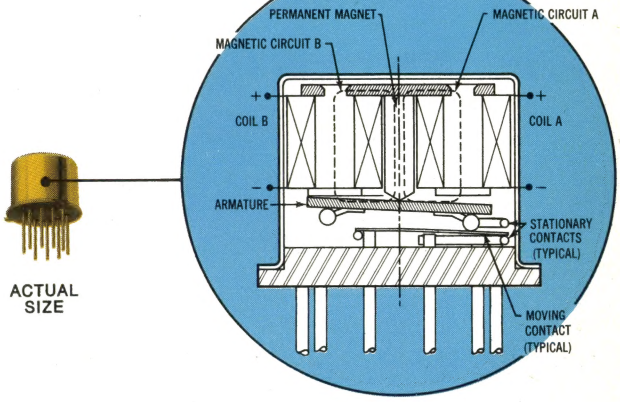
01906

*U.S. Domestic Price Only

CIRCLE NUMBER 3

TO-5 RELAY UPDATE

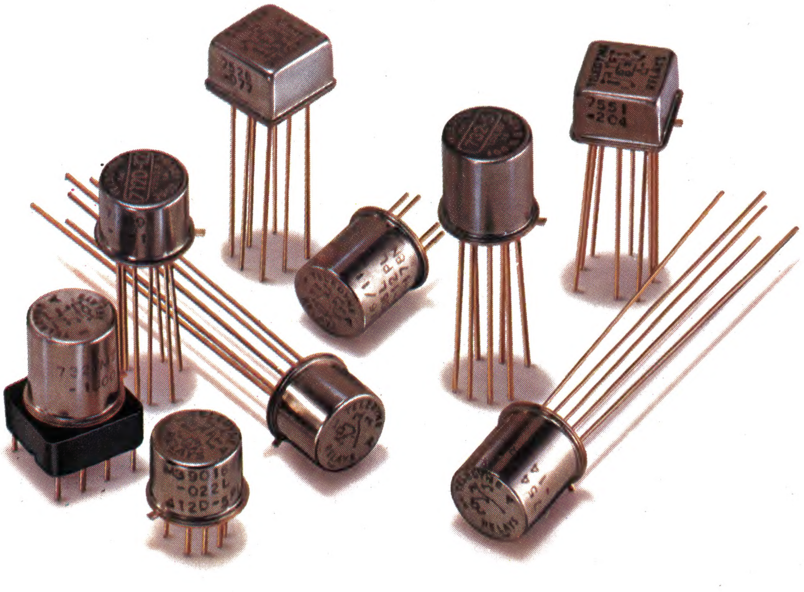
Maglatch TO-5: the relay with a mind of its own.



Whenever critical switching circuits call for reprogrammable non-destructible memory, choose Teledyne's magnetic latching TO-5 — the relay that remembers. Once set with a short pulse of coil voltage, it will retain its state until reset or reprogrammed — even if system power fails or is shut off. And you get the added advantage of reduced system power demands, since conventional relay holding power is not required.

But reprogrammable memory capability and low power consumption are not the only advantages of our TO-5 maglatch relays. Their subminiature size makes them ideal for high density pc board packaging, and they're available in SPDT, DPDT and 4PST contact forms. And for RF switching, their low intercontact capacitance and contact circuit losses provide high isolation and low insertion loss up through UHF.

Our magnetic latching as well as our complete line of TO-5 relays includes military and commercial/industrial types with MIL versions qualified to "L" and "M" levels of established reliability specs. For complete data, contact Teledyne Relays — the people who originated the TO-5 relay.



OTHER TELEDYNE TO-5 RELAYS

- **Hybrid "T" Series**
  SPDT & DPDT types with internal transistor driver and suppression diode. Military and commercial/industrial versions.
- **"D" and "DD" Series**
  With internal suppression and steering diodes. Military and commercial/industrial versions.
- **Centigrid® Series**
  World's smallest relay—only .225″ (5.72mm) high x .370″ (9.40mm) square. DPDT, with optional internal suppression and steering diodes.
- **Hi-Rel Series**
  Screened versions for space flight applications (NASA qualified).
- **High Environment Series**
  Hi-temperature, Hi-shock, and Hi-vibration types.

## TELEDYNE RELAYS

12525 Daphne Avenue, Hawthorne, California 90250 • (213) 777-0077
U.K. Sales Office: Heathrow House, Bath Rd. MX, TW5 9QQ • 01-897-2501
European Hqtrs.: Abraham Lincoln Strasse 38-42 • 62 Wiesbaden, W. Germany • 6121-700811

CIRCLE NUMBER 4

Electronic Design®

VOL. 28 NO.
3
FOR ENGINEERS AND ENGINEERING MANAGERS — WORLDWIDE
FEB. 1, 1980

Publisher:
Laurence Altman
Editor:
Lucinda Mattera
Executive Editors:
Stephen E. Scrupski
Stanley Runyon
Senior Editors:
avid Bursky, Morris Grossman, Sidney Adlerstein
Technology Editors:
Analog Circuits & Components: Stephan Ohr
Circuit Design & Professional: Donald Mennie
Communications: Sidney Adlerstein
Computers & Peripherals: Leonard Yencharis
Instruments: Jonah McLeod (Sunnyvale)
Packaging, Production & Power Sources:
Morris Grossman
Semiconductors: David Bursky (Sunnyvale)
oftware & Systems Integration: Max Schindler
Field Bureau Editors:
Eugene Heftman, New York
Ronald Shinn, Los Angeles
New Products Editor:
Harold Winard
Copy Editors:
James Keane
Sharon Bailly
Production Editors:
Marjorie Duffy
Assistant, Edward Connolly
Art Director: William Kelly
Assistant Art Director: Anthony J. Fischetto
Illustrator: Thomas Blaine
Editorial Secretaries:
Jane Merkel, Mary James,
Jeanine Lawson, Faye Clarke

Business Manager:
Thomas E. Vachon
Administrative Assistant:
Susan G. Apolant
Executive Secretary:
Jerri Strasser
Advertising Production:
Manager, Edward J. Grimm
Paul InCalcatera, Frank Murphy, Sharon Roden
Circulation:
Director, Barbara Freundlich
Senior Assistant, Gail Stone
Reader Service:
Paula Greenleaf
Promotion:
Director, Robert Pavone
Manager, Jay McSherry
Reprints:
Maxine Sassano
Editorial Offices:
50 Essex St.
Rochelle Park, NJ 07662
(201) 843-0550
TWX: 710-990-5071
(HAYDENPUB ROPK)
Cable Haydenpubs Rochellepark
West Coast:
8939 S. Sepulveda Blvd., Suite 414
Los Angeles, CA 90045
(213) 641-6544
TWX-1-910-328-7240

1307 S. Mary Ave., Suite 212
Sunnyvale, CA 94087
(408) 736-6667

News & Technology

23 **Universal fiber-optic receiver** handles any photodetector.
24 **Pascal validation programs** give full checkout.
24 **Memory, peripheral sessions at ISSCC**—rich in new devices.
26 **High-μ, low-loss transformer** cores use amorphous metal.
28 **Universal macro assembler** gets ready for 16-bit μPs.
30 **Two-chip keyboard** eases terminal designs.
33 **Circular thick-film resistor** designs trim up R-C networks.
32a **International section**
41 **Special Report:** ATE takes on LSI.

Design Engineering

50 **Capture fast waveforms** with a programmable digitizer (cover).
59 **Testing codec ICs** takes accurate stimulation, extensive software.
65 **Signature analysis**—the choice between two approaches.
75 **ATE with signature analysis** speeds LSI-board testing.
85 **High-frequency switching supplies** require component selection.
94 **Ideas for Design:**
Two 7-segment display drivers give nonstandard characters.
Triac trigger uses half-cycle ac triggering to set motor rotation.
Frequency doubler rejects harmonics without tuned circuits.

New Products

101 **Communications:** Fiber-optic cables gain strength at reduced size.
102 LSI synthesizer family brings low-cost versatility to rf comm.
107 **Microsystems:** Enclosure 'racks up' Q-bus systems.
108 Smart disk controller gives 40 Mbytes of storage.
110 **Components:** Triac drivers provide logic control on 220-V ac lines.
111 Keyboard smartens up for process control.
112 MOSFET breakdown voltages climb higher.
115 **Computers:** Universal compiler adapts quickly to new chips.
120 **Instruments:** GPIB controller offers the right touch.
121 Analog Circuits
122 Digital Circuits
126 Design Aids
126 Evaluation Samples
127 New Literature

Departments

11 Reader Feedback
19 News & Technology Previews
35 From Washington
39 Editorial
129 NEW—Professional Perspectives
130 Employment Opportunities
144 Advertisers' Index
144 Reader Service Card

Cover: Instrument photo courtesy of Tektronix, Inc.

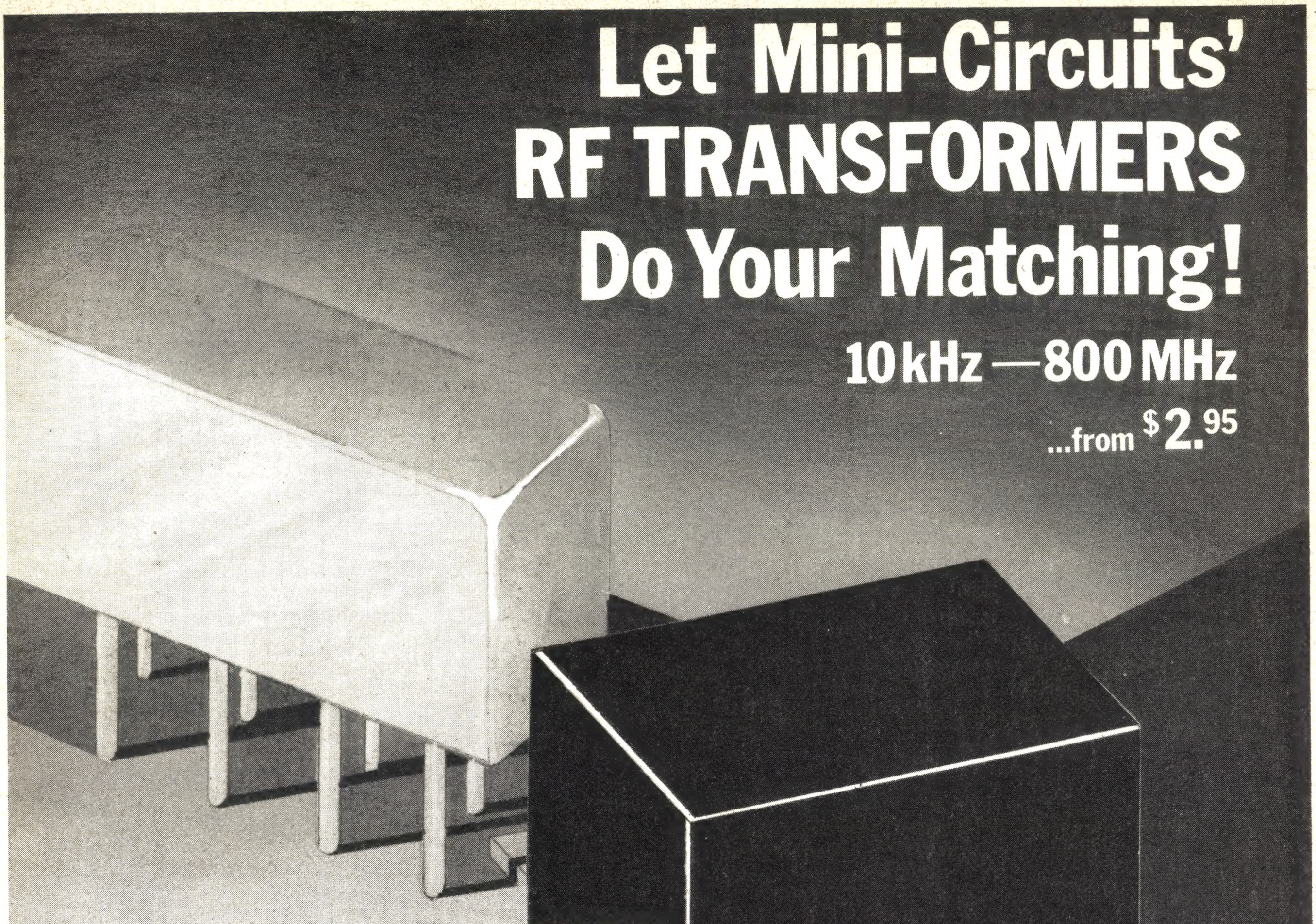
118,638 copies of this issue printed.

ELECTRONIC DESIGN (USPS-172-080) is published biweekly except 3 issues in July by Hayden Publishing Company, Inc., 50 Essex St., Rochelle Park, NJ 07662. James S. Mulholland Jr., President. Printed at Brown Printing Co., Waseca, MN. Controlled circulation postage paid at Waseca, MN, and New York, NY. Postage pending Rochelle Park, NJ. Copyright© 1980 Hayden Publishing Company, Inc. All rights reserved. POSTMASTER: Please send form 3579 to ELECTRONIC DESIGN, P.O. Box 13803, Philadelphia, PA 19101.

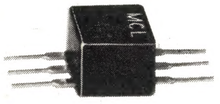
Let Mini-Circuits' RF TRANSFORMERS Do Your Matching!

10 kHz — 800 MHz

...from $2.95

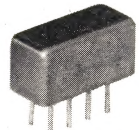


(Actual size)



Models T, TH (Plastic case)
(0.300" sq. × 0.230" high)

(Actual size)



Model TMO (Metal case)
(.500" L × .230" W × .255" h)

DC ISOLATED PRIMARY & SECONDARY

Model No.	Imped. ratio	Freq. (MHz)	Price (10-49)
T1-1	1	.15-400	$2.95
TM01-1	1	.15-400	$4.95
● T1-1H	1	8-300	$4.95
T1.5-1	1.5	.1-300	$3.95
TM01.5-1	1.5	.1-300	$6.75
T2.5-6	2.5	.01-100	$3.95
TM02.5-6	2.5	.01-100	$6.45
T4-6	4	.02-200	$3.95
TM04-6	4	.02-200	$6.45
T9-1	9	.15-200	$3.45
TM09-1	9	.15-200	$6.45
● T9-1H	9	2-90	$5.45
T16-1	16	.3-120	$3.95
TM016-1	16	.3-120	$6.45
● T16-1H	16	7-85	$5.95

● Up to 100mA DC without saturation

CENTER-TAPPED DC ISOLATED PRIMARY & SECONDARY

Model No.	Imped. ratio	Freq. (MHz)	Price (10-49)
T1-1T	1	.05-200	$3.95
TM01-1T	1	.05-200	$6.45
T2-1T	2	.07-200	$4.25
TM02-1T	2	.07-200	$6.75
T2.5-6T	2.5	.01-100	$4.25
TM02.5-6T	2.5	.01-100	$6.75
T3-1T	3	.05-250	$3.95
TM03-1T	3	.05-250	$6.45
T4-1	4	.2-350	$2.95
TM04-1	4	.2-350	$4.95
● T4-1H	4	8-350	$4.95
T5-1T	5	.3-300	$4.25
TM05-1T	5	.3-300	$6.75
T13-1T	13	.3-120	$4.25
TM013-1T	13	.3-120	$6.75

UNBALANCED PRIMARY & SECONDARY

Model No.	Imped. ratio	Freq. (MHz)	Price (10-49)
T2-1	2	.025-600	$3.45
TM02-1	2	.025-600	$5.95
T3-1	3	.5-800	$4.25
TM03-1	3	.5-800	$6.95
T4-2	4	.2-600	$3.45
TM04-2	4	.2-600	$5.95
T8-1	8	.15-250	$3.45
TM08-1	3	.15-250	$5.95
T14-1	14	.2-150	$4.25
TM014-1	14	.2-150	$6.75

FOR ADDITIONAL INFORMATION, COMPLETE SPECIFICATIONS, AND PERFORMANCE CURVES, REFER TO 1979-80 MICROWAVES' PRODUCT DATA DIRECTORY pgs. 161 to 368 or 1979 EEM 2770 to 2974.

It's easy to transform impedance and reduce VSWR.

Chose from 40 models, 12.5 to 800 ohms, 10 kHz to 800 MHz, ultra- low distortion (H models) balanced, unbalanced and center-tapped . . . immediate delivery . . . at prices that can't be matched, starting at $ 2.95

World's largest manufacturer of Double-Balanced Mixers

Mini-Circuits

MINI-CIRCUITS LABORATORY
A Division of Scientific Components Corp.

2625 East 14th Street Bklyn, New York 11235 (212) 769-0200
Domestic and International Telex 125460 International Telex 620156

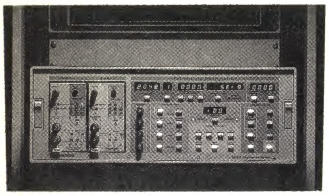
R 42/Rev/A

CIRCLE NUMBER 5

Contents Spotlight

Special Report: ATE rises to the LSI challenge
The proliferation of LSI circuitry—both analog and digital—is pushing automatic test equipment to more and faster testing, both at the component and board level. Another growing requirement is to isolate faults on boards discovered to be operating below spec. ATE manufacturers, it turns out, are equal to the challenge. Their response includes higher clock rates for analog LSI circuits and effective ways to check boards combining analog and digital circuits.

p. 41



Programmable digitizer accurately captures fast waveforms
The growth in computer power and in the sophistication of signal-analysis algorithms has called forth new methods of converting high-speed waveforms to digital form for detailed analysis by the computer. The Tektronix 7612D, essentially a high-speed analog-to-digital converter with digital memory, combines a CRT with an electron-bombarded semiconductor target to achieve the required fast sampling rate with good resolution.

p. 50

Digital test systems face the codec-testing problem
Testing a monolithic codec within a larger system may obscure problems, not uncover them. But hardware and software modules from digital test systems that are already widespread in the industry can put codecs through their paces on their own. With the hardware to ensure proper chip stimulation and with software to mathematically filter and analyze the output signals, a digital test system will measure all of a codec's parameters in less than 10 seconds.

p. 59

SA probes faults of memory and microprocessor boards
Signature analysis graduates to production ATE for memory and microprocessor boards, with the aid of a μP driven by a few hundred bytes of firmware. The internal logic structure of the board's devices may be completely unknown—yet normal operating modes can still be verified. Typically, faults are isolated in less than 15 seconds at the component level and a go/no-go test takes under 1 second.

p. 75

In the February 15 issue:

SPECIAL ISSUE ON INTEGRATED CIRCUITS... Key developments at the International Solid-State Circuits Conference... Plus: Learning the operating modes of the MC6801... Designing with Fairchild's IEEE-488 bus-interface chip... Putting in Intel's DMA controller chip... First design details of a RAM/EEPROM chip.

Advanced Micro Devices began by making the best integrated circuits in the business. We've built our reputation on microprocessors, memories, digital and linear peripherals and development systems. A $225-million dollar reputation.

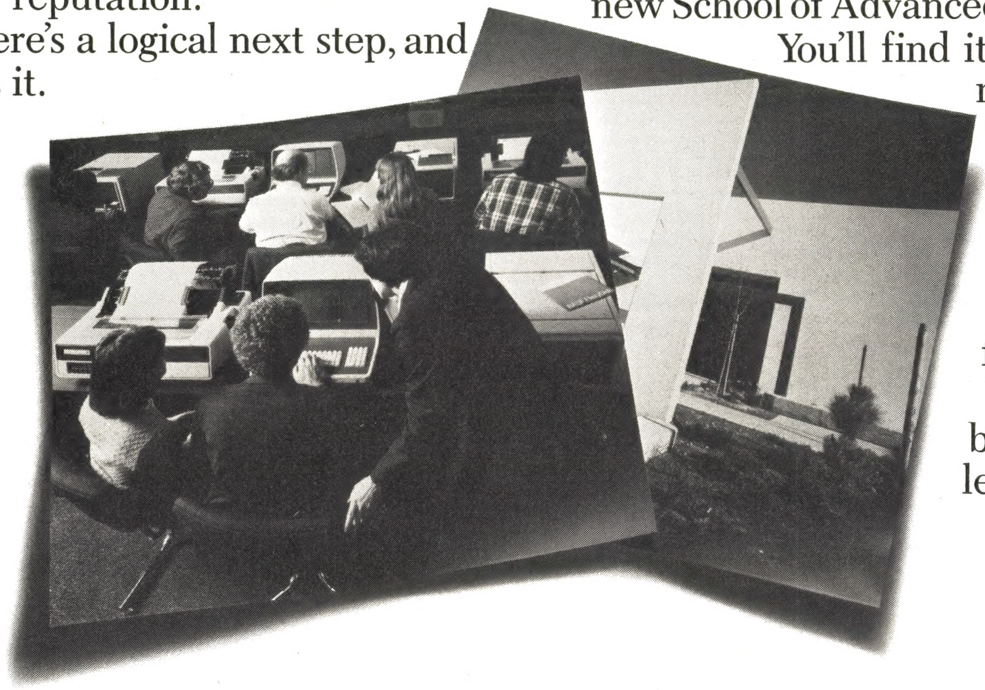
There's a logical next step, and this is it.

ANNOUNCING THE ADVANCED MICRO DEVICES SCHOOL OF ADVANCED ENGINEERING.

If you'd like to know all there is to know about our parts, come to our new School of Advanced Engineering.

You'll find it in our Customer Education Center, a complete educational facility designed just for you.

There's no better way to learn all



FIRST THE PARTS. NOW THE SMARTS.

about the AmZ8000 and Am2900 families. To get hands-on experience with our development systems and evaluation boards. To find out about everything from microprogramming to PASCAL to microprogrammable computer architecture.

Although our School of Advanced Engineering is new, we've been teaching the courses for years. And our customers have told us our courses are the best. Clear. Quick. To the point.

Send in the coupon and we'll send you all the details on our School, our staff, our courses. If you can't come to us, don't worry. Ask us about arranging a seminar in your area.

For our European customers, we have facilities near you. Return the coupon to one of the European offices listed below.

The Advanced Micro Devices School of Advanced Engineering. Because these days, you need all the smarts you can get.

Advanced Micro Devices ED 2-1-80
School of Advanced Engineering
Select the appropriate AMD address
from those listed below.

Send me your brochure on seminars and workshops.

Personal Name____________________

Personal Title____________________

Company Name____________________

Town (with postcode)____________________

Country____________________

Advanced Micro Devices
901 Thompson Place, Sunnyvale, CA 94086

Advanced Micro Devices • France: European Marketing Centre, 27, Boulevard Général-Vautrin, 06400 Cannes, France, Tel: (093) 48.59.75. Silic 314, Immeuble Helsinki, 74, rue d'Arcueil, 94588 Rungis Cedex, France, Tel: (01) 686.91.86. **Belgium:** Avenue de Tervueren, 412, bte 9, 1150 Bruxelles, Belgium, Tel: (02) 771.99.93.
Germany: Rosenheimer Str. 139, 8 Muenchen 80, West Germany, Tel: (089) 40 19 76. **Italy:** Centro Direzionale, Palazzo Vasari, 3rd Floor, 20090 Milano 2, Italy. Tel: (02) 21.39.020.
United Kingdom: 16 Grosvenor Place, London SW1X 7HH, England, Tel: (01) 235-6388.

BIPOLAR 8K PROM

Now high speed at half power is a piece of cake.

Fairchild has just set the standard in 8K PROMs with the most important development of the past two years. Our new 93L451 low-power 1K x 8 PROM features industry-standard speeds, but we've cut the power in half.

We did it with Isoplanar-S, the newest version of Fairchild's Isoplanar process. Isoplanar-S also allows us to make our standard 8K PROM the fastest in the industry. And we plan to make even faster and denser devices in the near future, as Isoplanar-S technology evolves.

Isoplanar-S. The pièce de resistance.

Isoplanar-S is Fairchild's evolutionary new process for scaling down bipolar LSI geometries. With it, we'll be able to reduce dimensions of bipolar products from their current 4-micron geometry all the way down to 1 micron. That will mean incredible increases in speed and density, with substantial decreases in system power and cooling requirements. All of which translates into superior performance for your computer system.

Have your cake and eat it too.

Because of its lower junction temperatures, our 93L451 low-power PROM can offer your system five times better reliability than the competition's standard-power PROMs. And lower power dissipation means fewer problems getting heat out of the box. So now you can run cooler, but just as fast.

Our new PROMs are an excellent energy-saving solution for upgrading your established system. Or for designing into your new one. After you've had a taste of high speed at half power, you'll never be satisfied with anything less than Fairchild. For all the details, call your nearest Fairchild office.

COMPARISON WITH OTHER 8K PROMS

MANUFACTURER	PART #	T_{AA} MAX 0-75°C	I_{CC} MAX 0-75°C
FAIRCHILD	93450/51	55 ns	175 mA
HARRIS	7680/81	60 ns	170 mA
SIGNETICS	82S180/81	70 ns	175 mA
INTEL	3608/28	80 ns	190 mA
MMI	6380/81-1	90 ns	180 mA
FAIRCHILD	93L450/51	70 ns	85 mA
SIGNETICS	82LS181	175 ns	85 mA

France: Fairchild Camera & Instrument S.A., 121 Ave. d'Italie, 75013 Paris. Tel: 331 584 55 66. Telex: 0042 200614. **Italy:** Fairchild Semiconduttori S.P.A., Via Rosellini, 12, 20124 Milano. Tel: 02 6 88 74 51. Telex: 36522. **Germany:** Fairchild Camera & Instrument (Deutschland) GmbH, 8046 Garching Hockbruck, Daimlerstr. 15, Munchen. Tel: 089 320031. Telex: 52 4831 fair d. **England:** Fairchild Camera & Instrument (UK) Ltd., 230 High St., Potters Bar, Hertfordshire EN6 5BU. Tel: 0707 51111. Telex: 262835. **Sweden:** Fairchild Semiconductor AB, Svartengsgatan 6, S-11620 Stockholm. Tel: 8-449255. Telex: 17759.

FAIRCHILD

Shaping the future of LSI technology.

CIRCLE NUMBER 107

When you need LEDs or more than LEDs...

Dialight is the first place to look. We can help you do more with LEDs...because we've done more with them.

Discrete LEDs come in a variety of sizes, shapes, colors (red, yellow, green in clear or diffused), with or without built-in resistors.

Low cost logic state fault indicators for trouble shooting complex circuits. Designed for close density PC board mounting.

High-brightness bi-color LEDs (red/green) suitable for go/no-go situations. Designed with unique lenses for the extra visibility you'll want for your most critical applications.

Snap-in mounting LED indicators reduce labor cost. Available in red, yellow or green with or without built-in resistors.

Whatever you need in LEDs, Dialight's probably got it already. For your free 60-page selector guide and listing of our nationwide stocking distributors, contact us today.

DIALIGHT
A North American Philips Company

Dialight meets your needs.

Dialight, 203 Harrison Place, Brooklyn, N.Y. 11237 (212) 497-7600

CIRCLE NUMBER 7

Mayday, Mayday

In "Basic Underlies the Multiple Languages of Smart Instruments" (Oct. 11, p. 94), there is a significant error in the benchmark examples.

The original benchmarks for Basic dialects appeared in *Kilobaud* (June and October, 1977). The entries for 12-k Altair Basic, H11 Basic, Pet Basic, Tektronix Basic, and IBM 5100 Basic entered in your table of run times (Fig. 7) correspond to the values given in *Kilobaud*. However, the *Kilobaud* benchmarks were based upon A=K/2*+4−5 performed 1000 times, not A=K/2*3+4.5, which appeared in your article. An HP2647A ran your benchmark No. 1 in 27.2 seconds and the corresponding *Kilobaud* benchmark (No. 4) in 29.5 seconds—a 10% difference.

Harold S. Corbin

11714 Ibsen Drive
Rockville, MD 20852

Ed. Note: Somewhere along the way, the minus sign was changed to a period—an effect every ham-radio operator is familiar with. That's why the distress signal is no longer SOS.

Are engineering tests the test of an engineer?

How very surprising that the proposal for licensing of all engineers should come from the National Council of Engineering Examiners (Nov. 8, 1979, p. 37), of all people. These estimable gentlemen should be lauded for their selfless dedication to their duty—at least as they see it. The fact that it enlarges their bureaucracy and ensures their jobs must necessarily be taken as happy coincidence.

From my observations and experience with licensing exams, the relation to the requirements of the job is tenuous at best. Usually 90% of the test applies to someone else's job. Further, since the emphasis is on obscure details, the testing of the most important aspect of engineering is completely overlooked; namely, the ability to comprehend the engineering approach.

Because our field changes so rapidly, an engineer must understand the principles that underlie the details of the job even more than the details themselves. Look at all the tube engineers who failed to make the transition to transistors. Observe now the "three-wire men" who cannot cope with LSI and systems design. Each of these could have passed licensing exams during the time of their forte.

Recently a proposal was brought before the New Jersey state legislature that would have required the licensing of all wedding photographers, to prevent people from getting bad wedding pictures. That can't work, and neither can this.

Brian Diehm
Software Design Engineer

Tektronix, Inc.
P.O. Box 500
Beaverton, OR 97077

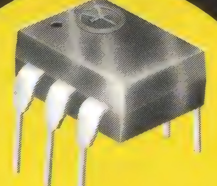
High-reliability marks new wave of transistors

We read your special report on microwave transistors (Dec. 6, 1979, p. 51) with interest and appreciation, but were extremely surprised that your list of suppliers did not include Power Hybrids Inc. Our company has been a volume producer of rf, microwave, silicon, bipolar transistors and microwave amplifiers since our inception in 1970.

As an example, we are just finishing deliveries of 50,000 high-reliability transistors we have manufactured for use in the Raytheon PAVE PAWS phased-array radars. The first site, which uses 25,000 Power Hybrids tran-

(continued on page 14)

Electronic Design welcomes the opinions of its readers on the issues raised in the magazine's editorial columns. Address letters to Editor, Electronic Design, 50 Essex St., Rochelle Park, NJ 07662. Try to keep letters under 200 words. Letters must be signed. Names will be withheld upon request.



TRW Optron
full line

DIP ISOLATORS
DIP ISOLATORS
DIP ISOLATORS

TRW Optron's complete line of optically coupled plastic DIP isolators offers immediate availability of standard devices for almost every application . . . plus competitive pricing, high reliability and excellent customer service.

Check these features and choose the device best suited for your application.

GENERAL PURPOSE
A full selection of DIP isolators with transistor and darlington outputs to match all popular industry standards. Current transfer ratios range from 2.0% to 500%.

HIGH VOLTAGE
For applications requiring an interface with high voltage circuits, select the OPI 6100 DIP isolator with a 200 volt output transistor.

AC OPERATION
The OPI 2500 DIP isolator features two input LED's operating in inverse parallel and is ideal for applications where the LED is driven from an AC line.

CUSTOM SELECTION
If your application demands "something a little different," TRW Optron specializes in DIP isolators to meet special customer requirements.

For reliability data and technical specifications on TRW Optron's complete line of plastic DIP isolators, contact your nearest TRW Optron sales representative or the factory direct.

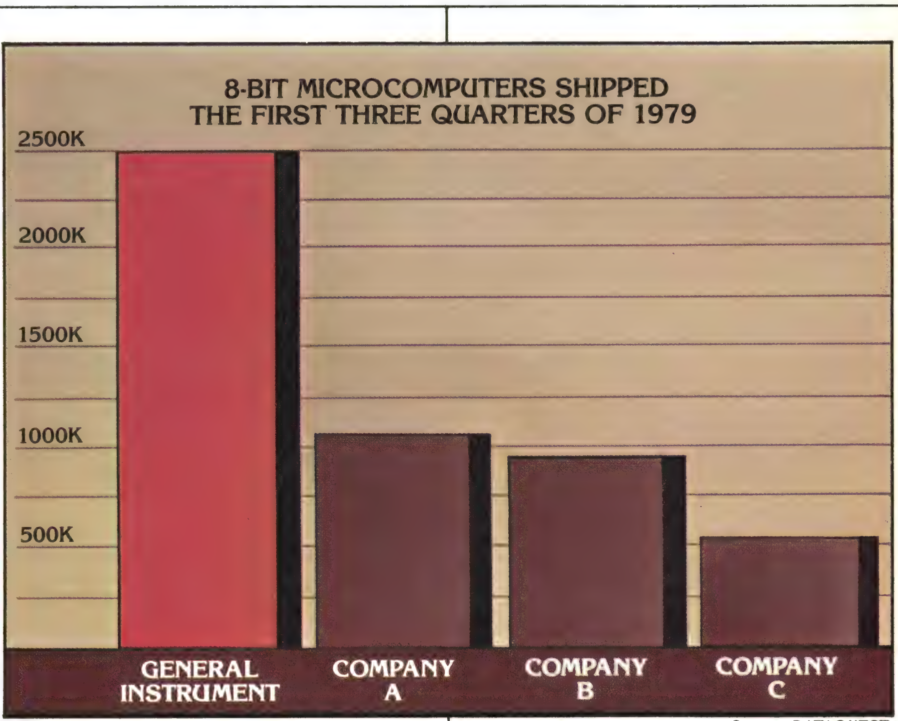
TRW OPTRON
A DIVISION OF TRW INC.
1201 Tappan Circle
Carrollton, Texas 75006, U.S.A.
TWX-910-860-5958
214/242-6571

CIRCLE NUMBER 8

We didn't get to the
the most 8-bit

The record speaks for itself. An independent survey revealed that during the first 9 months of 1979 General Instrument had topped all rivals by delivering over two and one-half million 8-bit microcomputers. That's more than twice as much as our nearest competitor.

While it is a most impressive record, to be sure, it's a direct reflection of the success and acceptance of General Instrument's philosophy: To provide products of consistent high quality, backed by comprehensive support and customer service, at competitive prices. Simply stated, we deliver more 8-bit microcomputers, because our microcomputers deliver more to our customers.

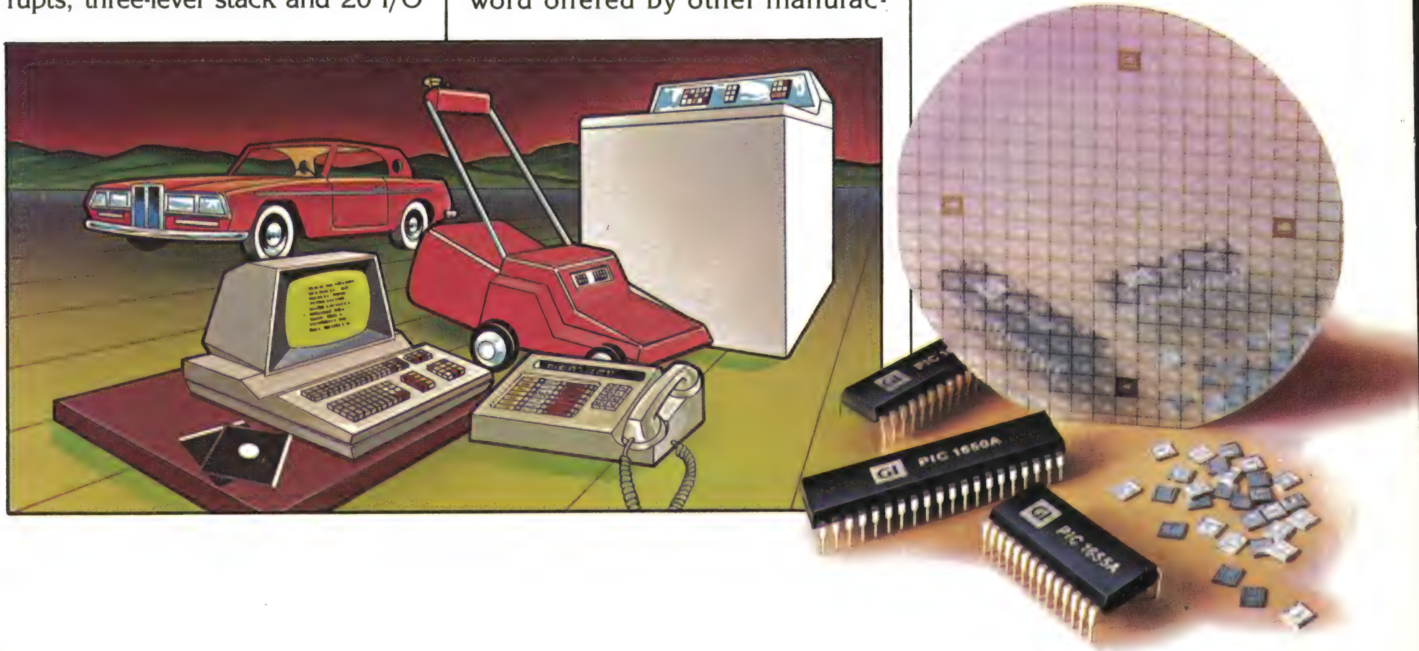


Source: DATAQUEST

Specifically, our popular PIC family consists of the PIC 1650A with 512, 12-bit words of Read-Only-Memory, 32, 8-bit bytes of RAM, 32 I/O lines, real-time clock counter and two-level stack, packaged in a 40-pin DIP. The PIC 1655A is a reduced I/O version,20 I/O lines, packaged in a space-saving 28-pin DIP. Another version, the PIC 1656, has both external and internal interrupts, three-level stack and 20 I/O lines in a 28-pin DIP. A development microcomputer, without the ROM, is also available.

All PIC series chips feature a powerful 12-bit instruction set, instead of the usual 8-bit instruction word offered by other manufacturers, which allows applications with far less ROM.

So much for what we make. What our customers make of it is something else again. Our 8-bit microcomputers have proven them-



top by just delivering microcomputers.

selves in a wide variety of applications, including vending machines, consumer appliances such as washing machines and vacuum cleaners, electronic games, keyboards, display drives, TV/radio tuning systems, industrial timers, motor controls, security systems and automotive dashboard instrumentation. And as long a list as we may come up with, it still isn't long enough, because even as you're reading this, someone is designing a PIC into yet another challenging product application.

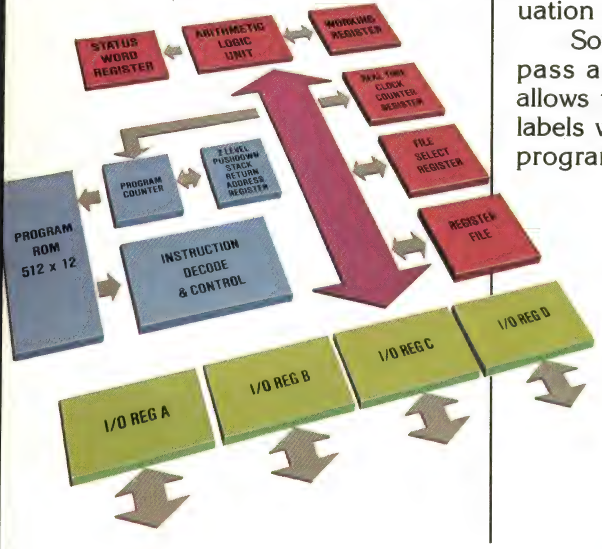
No matter how good a product may be — and ours is second to none — it needs the proper support to realize its full potential. Which is why we offer a complete, inexpensive set of hardware and software aids. This helps our customers in their design, development, and evaluation of a particular application.

Software includes PICAL, a two-pass assembler program, which allows the use of mnemonics and labels when writing the application program. By attaching our PICES In-Circuit Emulation System to any host computer, you instantly have a single-station PIC development system. Rounding out the support group is the PFD Series of PIC Field Demo systems which emulates the PIC Product Line, enabling the demonstration of an application program in the field before it's committed to a masked ROM.

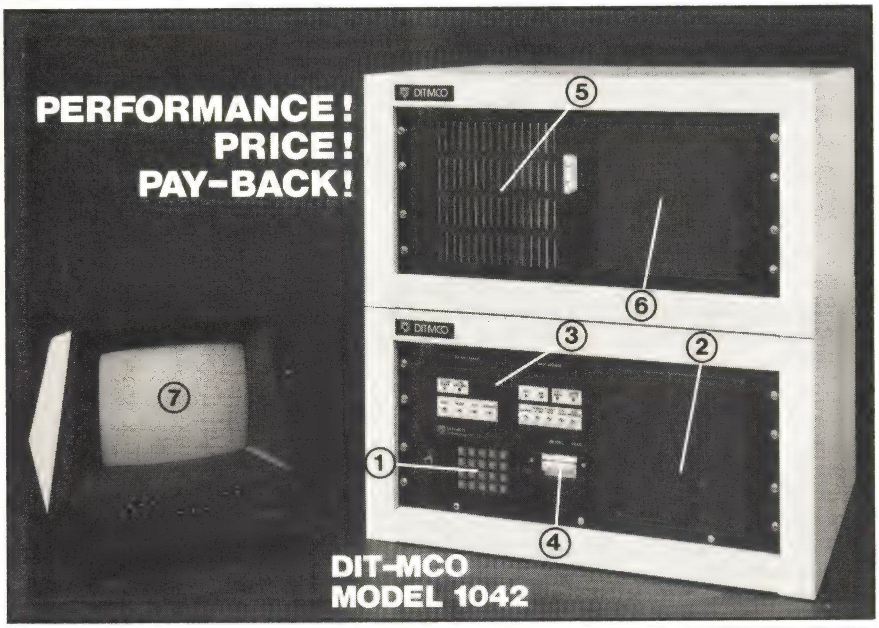
And, as you'd expect, we provide a complete library of information documenting all there is to know about our systems, including a PICAL User Manual, PICES Data Manual, PIC Handbook and PFD Series Data Manual — all yours for the asking. For more information, write or call General Instrument Microelectronics Ltd., Regency House, 1-4 Warwick St., London W1R 5WB, England, or call 01-439-1891.

We help you compete.

GENERAL INSTRUMENT



MPU Controlled Circuit Tester



Control Console:
1. Key Pad
2. Diskette Drive
3. Address Displays
4. Alphanumeric Printer

Switching Console:
5. 128-Termination Switching Modules
6. 4096-Termination Capacity Plugged for 2048T

CRT Operator Console:
7. Data Base Edit

Price Performance Factors Of Model 1042 Bring Test/QA Cost Savings To Areas Where Costs-To-Test Previously Were Marginal Or Prohibitive.

Model 1042 is a fully automatic, microprocessor controlled, high speed, solid state, self-programmable circuit tester featuring...

- Test program printout in both analyzer and UUT language.
- Pluggable solid state switching expandable to over 16,000 T capacity.
- Diskette test program storage.
- Data base edit capability.
- Product error printout.
- Test program listing on printer.
- Self program and playback.
- Assynchronous communications link with host computer and port for download batch transfer of test program.

The Model 1042 price-performance factors result in a highly cost effective test system. Coupled with a DIT-MCO "PREMIER LINE" access fixture it provides a test package offering the speed, versatility, flexibility, and overall test performance to sharply reduce throughput time and re-work costs.

Call or write now to see how your testing problems can be solved, economically, fast, and with a quick pay-back on equipment investment.

DIT-MCO INTERNATIONAL CORPORATION
The Difference in Testing!

5612 Brighton Terrace • Kansas City, Missouri 64130 • Telephone: (816) 444-9700
Telex Number 42-6149
European Technical Representative, RADIX HOUSE, Central Trading Estate, Staines Middlesex, TW18-4-XA, England, Telephone: (0784) 51444
TEL Shinjuku Nomura Bldg., 26-2, 1-Chome, Nishishinjuku, Shinjuku-ku, Tokyo 160, Japan, Tel: (03) 343-4411

CIRCLE NUMBER 9

Reader Feedback

(continued from page 11)

sistors, has been accepted by the Air Force and has been in continuous operation at Cape Code since April of this year. The system has far exceeded its reliability and maintainability goals. The second site is presently under construction at Beale Air Force Base.

Each power amplifier module in the array contains seven PHI transistors in a one, driving-two, driving-four configuration. Each output transistor produces 115 W of peak pulse power under long pulse conditions (10 ms, 20% duty), with a minimum 65% efficiency. Each array has more than 3500 of these modules.

PHI is involved in most of the RF microwave power-transistor markets from 30 MHz to 3 GHz.

Fred McAdara

Power Hybrids Inc.
1742 Crenshaw Blvd.
Torrance, CA 90501

Fiber-optic CRTs zap other technologies

In your "Focus on Plotters" (Oct. 11, 1979, p. 173), you made an error in describing Tektronix equipment. For CRT hard-copy output, Tektronix markets the 4631 (for storage-tube displays) and 4632 (for video sources), which use a fiber-optic CRT and dry silver paper to produce the image. The fiber-optic CRT technology produces clean, dry copies with excellent resolution and, in the case of video sources, fine gray scale as well. We do *not* market any products using the zap-matrix/aluminized paper approach, as your article indicated.

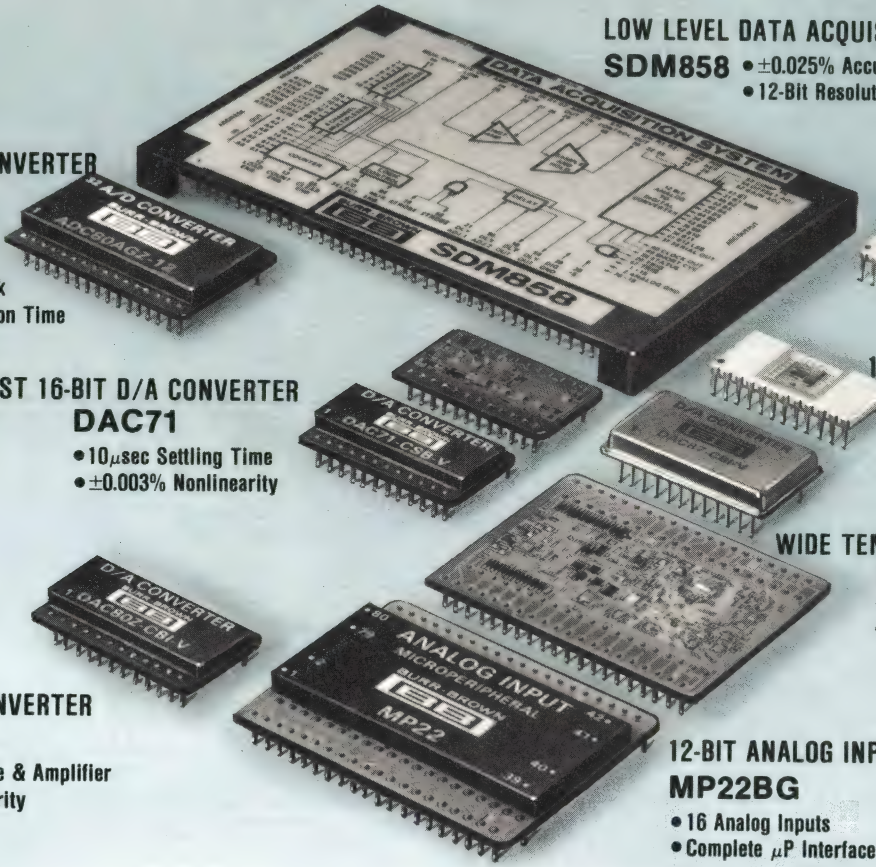
In addition, Tektronix provides CRT copy via our 4662 digital plotter (B size) and our 4663 digital plotter (C size).

Gerard H. Langeler
Business Unit Marketing Manager
Copiers, Plotters & Imaging Systems
Tektronix, Inc.
P.O. Box 500
Beaverton, OR 97077

Our mistake

The recent brief on Intel's 8272 controller (Jan. 4, 1980, p. 22) wrongly identified it as the second source of NEC's μPD 768. The 8272 is the second source of NEC's μPD 765 floppy-disk controller chip and costs $38.10.

TIME SAVERS



LOW LEVEL DATA ACQUISITION SYSTEM
SDM858
- ±0.025% Accuracy at G = 100
- 12-Bit Resolution

LOW COST
12-BIT A/D CONVERTER
ADC80
- Internal Reference, Comparator, Clock
- 25μsec Conversion Time

12-BIT MULTIPLYING
D/A CONVERTER
DAC862
- ±0.01% Nonlinearity
- Hermetically Sealed

LOW COST 16-BIT D/A CONVERTER
DAC71
- 10μsec Settling Time
- ±0.003% Nonlinearity

12-BIT CURRENT-OUT
D/A CONVERTER
DAC863
- Internal Reference
- Monotonic Over -55/+125°C

WIDE TEMP RANGE 12-BIT DAC
DAC87
- ±0.3% Accurate Over -55/+125°C
- DAC80/85 Pin Compatible

LOW COST
12-BIT D/A CONVERTER
DAC80
- Internal Reference & Amplifier
- ±0.01% Nonlinearity

12-BIT ANALOG INPUT SYSTEM
MP22BG
- 16 Analog Inputs
- Complete μP Interface

COMPLETE DATA CONVERSION PRODUCTS THAT MAKE YOUR DESIGN JOB EASIER

When you need 12- to 16-bit accuracy and conversion times from 0.3 to 25μsec, you'll find complete, easily applied solutions in our family of data conversion and data acquisition products.

These high performance products solve your design problems - save you time and installation costs, because they don't require external, active parts: plug in, power up and go! Choose from a full line of A/D, D/A, V/F, F/V, analog input/output, S/H, MUX and data acquisition products ... they're time savers!

Contact the Burr-Brown sales office in your area.

BURR-BROWN

Putting Technology
To Work For You

AUSTRIA - Wien 0222/62 63 71 - **FRANCE** - Le Chesnay, 954-3558 - **GERMANY** - Hauptniederlassung Filderstadt, 0711/70 10 25; Bremen, 0421/25 39 31; Neuss, 02101/30738; München, 089/61 7737; Berlin, 030/883 1058 - **HOLLAND** — Schiphol, (020) 470590 - **JAPAN** - Tokyo (03) 586-8141 - **SWITZERLAND** - Rüschlikon, 01/724 0928 - **UNITED KINGDOM** - Watford, (0923) 33837 - (Other areas contact) **Burr-Brown,** P.O. Box 11400, TUCSON, ARIZONA 85734 USA - Tel: (602) 746-1111 - TWX: 910-952-1111 - Telex: 66-6491 - Cable: BBRCORP

CIRCLE NUMBER 105

TOO HOT, TOO COLD, JUST RIGHT!

What type of switch offers the best overall keyboard cost structure? Ask the industry.

Capacitive designs offer switch cost structures equal to contact types, but with the reliability of a solid state switch. Furthermore, the economies of a non-soldered design more than offset the cost of simple 2-chip "drive and sense" circuitry.

Key Tronic offers you a 5 year record of reliability. With over 500 different designs and 500,000 keyboards in the field, we have the design expertise and manufacturing controls to make your keyboard selection 'just right'.

key tronic

INTERNATIONAL KEYBOARDS

P.O. BOX 14687 — SPOKANE, WASHINGTON 99214 U.S.A. PHONE (509) 928-8000 — TWX 510 773-1885

CIRCLE NUMBER 11

Introducing "The New Breed" of Monolithic Ceramic Capacitors

Vitramon, Incorporated—which introduced the first monolithic ceramic capacitor back in 1959—is now offering a new breed of high-quality components.

Known as the "VP" Capacitors, they are assembled automatically to reduce your costs—and they have an abundance of key design features.

The heart of each part is a high-quality NPO or X7R capacitor dielectric. The capacitor body, itself, is connected on two surfaces to a pre-formed lead—and the connection is strengthened by high temperature solder.

The rigid leads are short and rectangular for precise centering and positioning on circuit boards—and have a meniscus-free shoulder to enhance soldering operations.

"VP" Ceramic Capacitors are offered in three body sizes: capacitance values of 1.0 pF to 1.0 μF, and ratings of 100 and 50/63 Vdc.

In short, they're the *new breed* of monolithic ceramic capacitors—low in cost, yet they incorporate the highest quality materials.

At Vitramon, Incorporated, we think they're the best monolithic ceramic capacitors available. But don't take our word for it. Call or write for free samples—and judge for yourself.

Vitramon®

VITRAMON LIMITED
Wycombe Lane, Wooburn Green
Bucks, England
Tel. Bourne End 24933

VITRAMON GmbH
Postfach 16 01
7150 Backnang, W. Germany
Tel. 07191-62003

VITRAMON FRANCE S.A.R.L.
1, rue Felix-Eboue
94021 Creteil L'Echat, France
Tel. (1) 898-15-20

Other world Subsidiaries: Vitramon North America/Vitramon do Brasil Ltda./
Vitramon Pty. Limited/Vitramon Japan Limited

CIRCLE NUMBER 108

Your Guardian Angel invites you to

CHECK HER MEASUREMENTS

of these two "half-size" 13 amp relays.

These two small relays are about half the size of competitive relays that do the same job. The cost? About the same as those big competitive units. In many cases, a few cents less.

Choice of dual type (solder lug or 3/16″ QC) or printed circuit termination. Choice of solder lug, printed circuit or screw mount sockets.

1380

4 Form C (4PDT) contact arrangement.

1390

2 Form C (2PDT) contact arrangement.

Get all the facts on both these "half-size" relays. Send today for special technical bulletins that are yours free for the asking.

GUARDIAN®

®

GUARDIAN ELECTRIC MANUFACTURING COMPANY—1550 W. Carroll Avenue, Chicago, IL 60607—312/243-1100

CIRCLE NUMBER 13

Infrared imaging pins down PC-board solder-joint faults

A laser/infrared signature-analysis technique will help automatic test equipment eliminate difficult-to-diagnose solder-joint failures before they create problems in PC boards. Developed by Vanzetti Infrared and Computer Systems (Concord, MA) under subcontract from Battelle Research Lab (Columbus, OH), the technique joins a laser with Vanzetti's Inspect Infrared test system to detect the signatures of various solder-joint faults.

Solder-joint failures prove quite costly both for the board maker on the assembly line and for the field technician. Electronically comparing the signatures detected from a joint being tested with each known signature makes it easy to isolate faults that would not only cause immediate failures but also create problems after a time of normal operation.

The laser injects heat into the joint while the sensor produces its signature to determine how fast the joint accepts and gives off heat. The rate of acceptance and dissipation tell much about the quality of the solder joint itself. Recent Air Force studies have described 32 fault signatures for a solder joint as well as its one good signature.

Vanzetti is currently investigating an extension of this technique that would check the quality of solder-joint connections made between different layers of multilayer PC boards. Connections between layers are made via plated-through holes, with the exterior circular wall of the hole metalized to facilitate the connection. Insulation surrounds the wall at the layers where no connection is made. A 360° solder joint joins the hole's metal wall to the layer where a connection is made.

With the same laser technique, the hole can be injected with heat and a signature of the hole examined. The idea is to determine the same types of fault information as for the solder joint for each layer connection. To date, this has been impossible with conventional ATE, which had no access to the interior of a multilayer board.

Solder joints are not the only part of a PC board amenable to infrared analysis. Both the Inspect System from Vanzetti and the Model 900 Thermal Imaging System from UTI (Sunnyvale, CA) produce thermal images of PC boards themselves. Images are sensed with the board under full or partial power. By analyzing the thermal image visually, shorts or other overcurrent conditions can easily be spotted before damage can occur.

What's more, by analyzing the board thermal image with a computer, signatures of specific components on the board can be compared against known-good signatures for these components. In this way, troubles in these circuit devices can readily be detected and replaced.

Examining infrared images is not a new technique. Steadily, however, it has been gathering followers among customers desiring high reliability in their products. So far, the military and aerospace industries have been the primary buyers. In the future, however, the technique could gain followers in the commercial world when board makers start seeking tighter levels of reliability and reduced testing costs.

IC design system offers logical mask verification

Billed as the first system to verify both logical and physical designs at the mask level, the Integrated Computer-aided Design System (ICDS) offers hierarchical verification for LSI, VLSI and VHSIC chips. The ICDS from DMT Corp. (Nashua, NH) uses an IBM370, Prime or National CSS computer.

A symbolic layout in the ICDS replaces traditional mask data with shorthand symbols. The layout improves the screen-response time and reduces storage to a fraction of that needed in other systems.

The symbols are stored in a "cell library" and accessed through a menu. Another library (constructed from a circuit element) contains the geometric data, at each mask level, for constructing the device. Because hundreds of thousands of transistors are replaced by relatively few circuits, the ICDS easily modifies chip architectures and generates a new set of masks. Although symbolic layout systems (SLS) have been used for some time, ICDS is said to be the first commercial system that provides interactive design for an SLS.

A third library contains design rules and tests for each design step. The physical layout is checked against the circuit logic for elements ranging from a simple transistor to a complete ALU. Even an input file for circuit simulation is generated automatically.

Chip-component inserter ahead of standards

Although standards for packaging chip resistors and capacitors have yet to be settled upon by EIA committees, automatic insertion equipment for such components is already being prototyped. Universal Instruments (Binghamton, NY), for example, has developed the Model 4611 Microelectronic Hybrid Assembly System, which relies on a three-step process for placing chip components in place on a hybrid circuit substrate or PC board.

In the first step, the substrates are coated with a mild adhesive. In the second step, chip components with solderable end caps are placed on the board. In the third step, the board is heated and the chips soldered in place.

The mechanism that locates the chips on the hybrid and presses them into place uses a vacuum device to hold onto the chips while they are being centered and placed. The chips themselves can be loaded for insertion in plastic magazines, or the chips can be loaded in bulk form, and individually lined in place by a vibratory track.

Components are centered and inserted by computer controls similar to those used by Universal for leaded components. The 4611, to be highlighted at the Nepcon West Exhibition in Anaheim, CA later this month, can accommodate chip sizes from 0.030 in. square to 0.375 in. square.

Another manufacturer of component insertion equipment, the Panasonic Division of Matsushita (Secaucus, NJ), displayed chip insertion equipment in Western Europe at Productronika in West Germany last November, but thus far has not offered the equipment for sale in this country.

The interest in chip insertion equipment is spurred by new lines of chip components announced by overseas manufacturers such as R-Ohm (Irvine, CA), Panasonic, and domestic suppliers such as Mepco/Electra (Morristown, NJ). Most component insertion equipment manufacturers, however, are postponing an announcement on chip inserters until the packaging standards for chip components are fixed by the EIA. The size of the passives isn't at issue but the size and position of solderable interconnection tabs. The chips themselves will be useful in consumer applications requiring small size.

Retooled or not, connector plugs conform to standard

Multipin circular connectors that conform to the proposed Revision H of MIL-C-38999 reflect the different approaches of ITT Cannon (Santa Ana, CA) and Bendix Components Division (Sidney, NY).

ITT Cannon has incorporated a new coupling mechanism into its Series I-Plus connector plug to further guard against shock and vibration; the plug has improved environmental protection and specialized grounding fingers that improve EMI shielding. The Series I-Plus connector plug will follow the design approach taken by Amphenol North America (Oak Brook, IL). Because the Series I-Plus connector plug mates with the original Series I receptacle, inventory replacement costs can be limited.

Bendix, however, stands firm in refusing to retool its own four-year-old version of the Series I connector. Bendix states that its plug already meets the conditions of proposed Revision H, without a redesign or inventory replacement.

For severe environments, Bendix is advocating the threaded-plug design of its Series III, rather than the bayonet lock of the Series I.

Briefs

EXORmacs, a full development system for the MC68000 16-bit microprocessor is coming from Motorola Semiconductor (Phoenix, AZ). The system will use a new bus structure called VERSAbus, which the company says it is proposing "as a standard for all 16-bit and larger microcomputer systems." The first version will accommodate a single user with multitasking capabilities, but will be expandable in the future to a multiuser system by adding such options as a hard-disk memory.

The fastest ALU building block is now the MC10900 from Motorola (Phoenix, AZ). It should be available in the second quarter of 1980. Built from the company's MECL 10-k Macro-cell programmable array, the circuit performs an 8-bit add operation in less than 13 ns, including parity. When three of the ALUs are cascaded, a 24-bit add operation can be completed in less than 18 ns. Providing 8 bits plus parity, the expandable ALU slice contains logic functions, shift network, arithmetic unit, I/O latches and parity detect logic. It comes in a JEDEC standard 68-contact leadless package.

With low cost and excellent accuracy, a 100-channel scanner can use common thermocouple or RTD inputs. Systems built around the 2300A Scanner from John Fluke Manufacturing Co., Inc. (Mountlake Terrace, WA), expand in 10-channel steps, and cost $2000 to $5200. Comparable configurations using a data logger cost more than $10,000.

A microprocessor-based buffered disk controller that can handle up to 320 Mbytes has been announced by ICL Inc. (East Brunswick, NJ). The MDVC controller, part of ICL's System 10 Model 320 small business computer, will handle as many as four disk drives, each ranging in capacity from 20 to 80 Mbytes.

As many as 130,000 points on backplanes and bare PC boards get checked speedily by the new N161 Tester from Teradyne, Inc. (Boston, MA). Software developed specifically for the tester makes it fast, flexible and easy to operate.

GenRad Inc.—aiming to become a major supplier of LSI/VLSI semiconductor test devices—has formed a subsidiary, GenRad Semiconductor Test, Inc. (Santa Clara, CA). Brian Sear, president and general manager of the new enterprise, stated that the company would seek technology leadership in the testing of MOS and bipolar components. The first product will feature an architecture that involves networking and a clock that should be twice as fast as clocks in current high-performance test systems. Introduction is expected in late 1980 or early 1981.

Single-piece molded-rubber keyboards from Conductive Rubber Technology (Santa Barbara, CA) will lower the cost and improve the reliability of keyboards for consumer electronics. The single-piece keypad integrates printed key-top, spring-back mechanism and contact pad in one molded piece. Contact resistance is unusually low for an elastomeric—as little as 0.35 Ω—and operating life is better than 2-million cycles. Keyboards are custom-made by Shin-Etsu Polymer Corp. in Japan.

A series of single-chip monolithic driver/amplifiers will provide an open-loop gain of 104 dB, and a maximum output of ±25 V, to drive medium-powered (16-A) voltage-controlled MOSFET devices. The MA-500-CP amplifiers from Analog Systems (Tucson, AZ) come in 16-pin DIPs, with provisions for designer-selected outboard-feedback loops and for current limiting. Each amp requires a 30-V supply, but will function with little power consumption. Bias currents are 400 nA. Unity-gain bandwidth is 7 MHz.

"The best memory board tester is now even better!"

Introducing the Macrodata MD-207/11...

The Macrodata MD-207 is the most widely accepted memory board tester on the market today. But the new Macrodata MD-207/11 is a whole lot better.

Both systems have the versatility to dynamically test semiconductor memory boards and systems, as well as CCD, bubble, and combination memory/logic modules. And both machines are equally capable of being used as production tools on the manufacturing floor or for performing engineering characterization tests. As evidence of reliability, the basic design common to both systems has been field-proven in more than 100 MD-207 customer installations.

Now with the new versatile MD-207/11, the user can do everything he could do with the MD-207 but with the powerful added advantage of a DEC-LSI-11 computer and dual floppy disk storage. This gives him 1 megabyte on-line memory and also all the other benefits of a DEC-LSI-11 computer, such as compatibility with DEC peripherals and a greater facility for user enhancement of software packages. Plus, this added capability simplifies the controlling and monitoring of burn-in ovens while testing racks of memory boards.

All MD-207 test programs can be run on the new MD-207/11, and the MD-207 can be field upgraded with full MD-207/11 capability. For a new brochure on this next-generation Macrodata Memory Board/System Tester, contact Eaton Corporation, Semiconductor Test Systems Division, 21135 Erwin Street, Woodland Hills, CA., 91365. Phone: (213) 887-5550. Telex 69-8489.

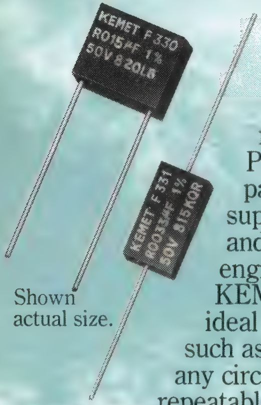
France: (01) 907 78 44
Germany & Switzerland:
(089) 903 73 73
Italy: (02) 4154 141/2/3
Japan: (03) 591 2261
Scandinavia: (08) 87 94 90
UK & Benelux: (0628) 32 336

EATON Semiconductor Equipment

CIRCLE NUMBER 14

THE 21st CENTURY IS HERE!

KEMET® Flat-Kap Precision Film Capacitors are an important part of it.



Shown actual size.

The General Dynamics F-16—called "the fighter aircraft of the 21st century"—displays unmatched maneuverability, versatility and dependability.

Contributing to this outstanding performance are KEMET Flat-Kap Parylene Film capacitors—an integral part of the Hamilton-Standard JFC-90 supervisory control, which monitors and fine-tunes the fuel flowing to the engine.

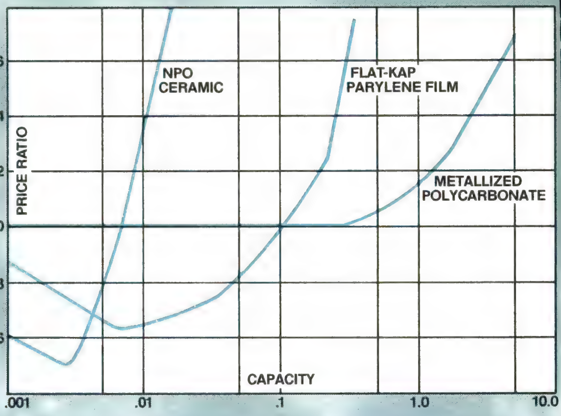
KEMET Flat-Kap capacitors are ideal for tight-tolerance applications such as this. In fact, they're ideal for any circuit where close tolerance, repeatable temperature coefficient and capacitance stability are essential. Because they combine small size, superior electrical characteristics, and the ultimate in stability in extreme environments.

They're available now in space-saving, rectangular hermetically-sealed or molded cases, with radial or axial leads, and extended values from 0.001 µF to 1.0 µF. Close tolerances to ± 1% are standard for molded parts, and to ± 0.5% for hermetically-sealed units.

Step up now to the next generation of ultra-stable capacitors—KEMET Flat-Kap Parylene capacitors, now available to R level per MIL-C-55514/3.

For more data, write to Electronics Division, Union Carbide Corporation, Box 5928, Greenville, SC 29606. Phone: (803) 963-6300; TWX: 810-287-2536; Telex: 57-0496. Or see your local KEMET representative.

CAPACITANCE/PRICE COMPARISON
(For MIL Spec, 50 Volt, ±1% Tolerance Units)



PHYSICAL AND PERFORMANCE CHARACTERISTICS

PARYLENE VS. VARIOUS DIELECTRIC MATERIALS

Characteristic	KEMET* Parylene	Polystyrene	Polycarbonate	Polyester	Mica	NPO Ceramic	Glass
*Size (P.C. Board Volume)	.0175 in³	.143 in³	.0164 in³	.044 in³	.141 in³	.0625 in³	.082 in³
STABILITY (Temperature Coefficient in PPM/°C)	Characteristic A −200 ±30 B 0±100 C 0±50	−120±30	Varies to ±350	+1150	Characteristic C +200 D±100 F-0 to +70	0±30	+180
ELECTRICAL Dissipation Factor—% at +25°C	0.10	0.10	0.15	0.40	0.10	0.10	0.10
Insulation Resistance Megohm at +25°C	1 x 10^7	1 x 10^6	3 x 10^6	1 x 10^5	5 x 10^4	1 x 10^5	1 x 10^7
Dielectric Absorption	0.03	0.02	0.1	0.25	4.80	0.29	5.10

*Per applicable military specification. Flat-Kap Parylene capacitors are described in MIL-C-55514 for a 0.1 µF capacitor.

KEMET® OFFERS YOU MORE.

See pages 1222 through 1282 of EEM for KEMET Capacitors condensed catalog.

UNION CARBIDE **ELECTRONICS DIVISION COMPONENTS DEPARTMENT**

KEMET is a registered trademark of Union Carbide Corporation.

In Europe: Union Carbide Europe, S.A. 5, Rue Pedro-Meylan,
Geneva 17, Switzerland. Phone: 022/47 4411. Telex: 845-22253.

CIRCLE NUMBER 15

Universal fiber-optic receiver-amp works over wide sensitivity range

Faced with a wide variety of fiber-optic detectors, a designer would be hard pressed to come up with a receiver that matches the desired performance for each new system. However, with a new universal low-noise receiver-amplifier from National Semiconductor (Santa Clara, CA), performance is adjustable simply by adding a few components to set input sensitivity. What's more, a FET-input preamplifier makes possible a high level of performance over a wide sensitivity range.

The LH0082 can operate at high speed as a current-to-voltage converter or as a voltage amplifier with pin or avalanche photodiodes, phototransistors and even photomultipliers. The DIP-packaged unit includes a FET-input amplifier with 3 GHz of gain × bandwidth, a voltage reference, a comparator with hysteresis, and all the feedback and coupling resistors and capacitors required.

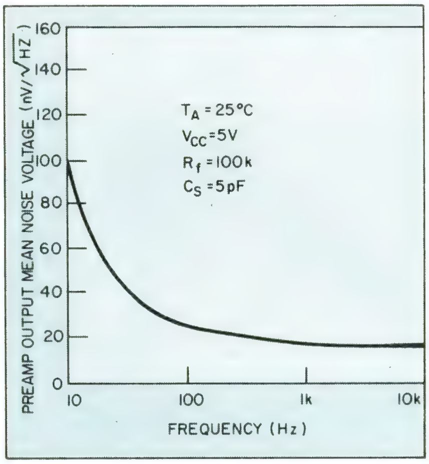
Analog, digital outputs

Separate analog and digital outputs add to the circuit's versatility. The digital-output signal can be compatible with CMOS, TTL and DTL levels, at NRZ data rates from dc up to 15 Mbits/s using the device's internal comparator.

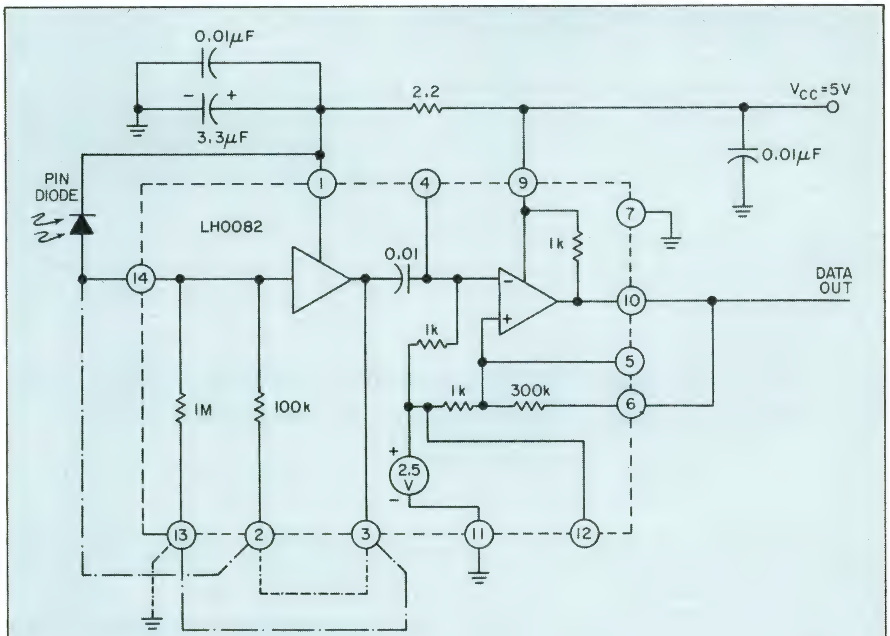
Adding an external comparator, such as National's LM160, boosts the NRZ data rate to a speedy 50 Mbits/s while still maintaining a 10^{-9} bit error rate (BER). Moreover, using just typical pin photodiodes, with responsivity of 0.5 A/W and capacitance of 3 pF at 2.5-V reverse bias, low or high-sensitivity operation can be selected using the internal feedback resistors. Maintaining a constant BER of 10^{-9}, of course, requires the data rate to decrease as the sensitivity increases. With a low sensitivity of 300 nW, the LH0082 passes data from dc to 6 Mbit/s; with a high sensitivity of 30 nW, data rates range from dc to only 1 Mbit/s. An external feedback resistor can make the amplifier even more sensitive—up to 5 nW, but then the data rate is limited to 1 kbit/s.

The high performance over the wide sensitivity range stems from the noise-performance preamplifier, a FET-input circuit that has a noise "floor" of 0.5 nW in both the sensitivities. The output noise is 200 μV rms over a 10-Hz to 10-MHz range. Noise-equivalent power is 5 nW in the low sensitivity range of 300 nW, dropping to 0.5 nW at 30-nW sensitivity.

Equivalent rms noise input current



Mean noise voltage at the preamp output stays low past 100 Hz even with the circuit connected in its low-sensitivity mode (r_f=100 k).



A simple wiring change at just four pins of the LH0082 switches the circuit from 300-nW sensitivity and 6 Mbits/s to 30 nW and 1 Mbit/s.

Sid Adlerstein
Communications Editor

from 10 Hz to 10 MHz at low sensitivity is 2 nA, falling to 200 pA at high sensitivity. The voltage gain is 80 and the quiescent output voltage drifts −6 mV/°C.

Additional sensitivity can be gained by operating a phototransistor detector in the transistor-mode ac, according to Dave Long, the unit's product marketing manager. He cautions that the result will be slower circuit response and decreased dc stability due to beta multiplication of the phototransistor dark current.

At any rate, avalanche-photodiode detectors can be used with the amplifier to raise the overall speed and sensitivity. For maximum data rates the comparator output should see a minimum capacitive load.

Long considers the LH0082 the first of a high-performance line of low-cost fiber-optic products. National claims that the 100-quantity price of $27 each is from one-third to one-half that of lower-performance competitors. The unit also comes in more expensive military-temperature-range versions, and can be processed to meet MIL-STD-883 requirements. ■■

Test programs judge validity and quality of Pascal implementations against standard

Max Schindler
Software Editor

A collection (or suite) of 283 programs will test the compliance of Pascal implementations with the standard of the International Standards Organization. The validation suite tests for conformity (133 programs), deviance (68), error handling (45) and quality (21); 16 programs cover features related to implementation.

The originator of the program is Prof. A.H.J. Sales (University of Tasmania, Australia). He claims that "everybody who markets a Pascal implementation should use a validation suite to check out his processor."

The conformity tests check whether the processor performs all standardized Pascal functions properly. If all conformity tests execute without a hitch, the printout PASS is generated. However, iteration depth and irregularity may pose problems even for a "healthy" processor, since no finite machine can provide infinite recursion. Thus, a minimum case and a plausible multiple are used for applicable constructs.

The deviance tests determine whether expressly forbidden constructs are indeed detected and suppressed. One optimizing compiler, for instance, was found to treat constants that are powers of 2 differently from other integers; as a result, the operation J DIV K yielded different answers for the same value of K to the second power, depending on whether K had been declared a constant.

Error tests are similar to deviance tests—they check whether conditions that are specified as errors in the standard produce the proper messages. Implementation-defined features are accepted if they have been documented properly.

In addition to these tests against the standard, 21 programs assess the quality of an implementation: Does the processor unduly limit the number of nesting levels or the recursion depth? How accurately does it compute SQRT (X)? Does it go into an infinite loop? How good are the diagnostics? This group of tests is bound to grow as more implementations become available.

The complete source code of the suite appeared in *Pascal News* (October, 1979). However, since the validation suite comprises about 12,000 lines of code, it would be impractical (as well as illegal) to copy it. The issue is available for reference from Pascal User's Group, c/o the Atlanta Sales Office of Digital Equipment (Rick Shaw, 404-242-2600); the cost is $3. The whole package on nine-track tape is available for $50 from Richard Cichelli, ANPA Research Institute, Box 598, Easton, PA 18042. In Europe, details are available from Dr. Wicham, National Physics Laboratory, Teddington, TW11 OLW, England.

As with any test for a computer program, the validation suite will contain errors that can be uncovered only after extensive use. To acquire the feedback needed to improve the programs and to survey the performance of Pascal processors, Prof. Sales has included in his test package three standard forms to report on the validation suite itself. The forms should be returned to the Department of Information Science, University of Tasmania, P.O. Box 252C, Hobart, Tasmania, 7001, Australia. ■■

LSI and memory processes make big push in size and speed at ISSCC

Dave Bursky
Semiconductors Editor

Keeping pace with the strong advance of microprocessors, LSI peripheral circuits and memories keep growing in speed, complexity and density. The International Solid State Circuits Conference in San Francisco, CA, will bring news of many device and process advances in both areas:

- LSI circuits to be discussed include a powerful floating-point math processor and a bubble-memory system chip set from Intel (Santa Clara, CA), advanced CPU and ALU designs by Fujitsu and NEC-Toshiba Information Systems (both from Japan), and a speedy CPU chip set by Data General (Westboro, MA).
- EPROMs and dynamic RAMs will share center stage, with most of the major manufacturers on hand to discuss 64-kbit UV EPROMs, 16-kbit EEPROMs, 16-kbit bipolar PROMs, 64-kbit dynamic RAMs and 16-kbit bytewide static devices. Texas Instruments (Houston), for example, will offer a detailed look at its 64-k × 1 dynamic RAM—the first glimpse of the inside.

Details, details

Another 64-kbit RAM will be described by Hitachi—a 5-V-only device that offers a 300-ns cycle time, 170-mW power dissipation and a chip area of less than 40,000 mil^2. On a more general RAM note, IBM will show how to use 1/N fractional devices in bipolar dynamic RAMs. Equivalent to single-transistor cells in NMOS mem-

AM, FM, PHASE LOCK, SWEEP, 30MHz, AND MUCH MORE...

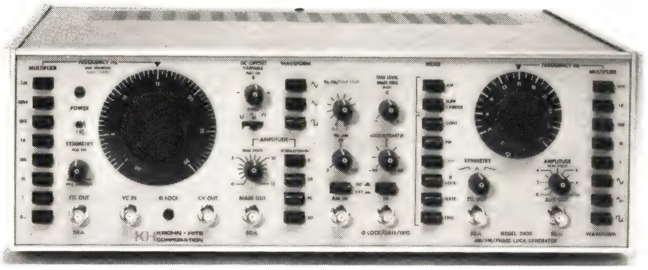
You've Wished For It All In A Function Generator

Once you've experienced the versatility of the new 2400 two-in-one function generator, others just won't measure up to your standards. Krohn-Hite has designed two truly independent generators in one package to make the 30MHz Model 2400 unique.

You can use the main and auxiliary generators individually to produce sine, square, triangle, ramps, and pulses. You can combine them for phase lock outputs with phase shifting control. And you can also produce triggered, gated, pulse, and tone burst waveforms.

The versatile 2400 is priced at $1495. (domestic price only). Put it to the test today. Call Krohn-Hite for further information and look up our complete product listings in EEM and Gold Book.

KROHN-HITE CORPORATION
Avon Industrial Park, Avon, MA 02322 • (617) 580-1660 TWX 710 345 0831



© Krohn-Hite Corp. 1979

Krohn-Hite . . . Benchmark of Value in Function Generators

SALES OFFICES: **AL.**, Huntsville (205)534-9771; **AZ.**, Phoenix (602)279-1531; **CA.**, Inglewood (213)674-6850, San Jose (408)292-3220; **CO.**, Denver (303)773-1218; **CT.**, Canton Center (203)693-0719; **FL.**, Orlando (305)859-7450, Sunrise (305)742-2115; **GA.**, Atlanta (404)455-1206; **HI.**, Honolulu (808)941-1574; **IL.**, Chicago (312)283-0713; **IN.**, Carmel (317)844-0114; **KS.**, Overland Park (913)649-6996; **LA.**, Gretna (504)367-3975; **MD.**, Towson (301)321-1411; **MA.**, Wakefield (617)245-5940; **MI.**, Detroit (313)961-3042; **MN.**, Minneapolis (612) 835-4818; **MO.**, St. Louis (314)569-1406; **N.M.**, Albuquerque (505)255-2330; **N.J.**, Cherry Hill (609)482-0059, Englewood (201)871-3916; **N.Y.**, Rochester (716)473-5720, Syracuse (315)437-6666, Vestal (607)785-9947; **N.C.**, Burlington (919)227-3639; **OH.**, Chesterland (216)729-2222, Dayton (513)294-2476; **OK.**, Jenks (918)299-2636; **OR.**, Portland (503)297-2248; **S.C.**, Greenville (803)271-8543; **TX.**, Dallas (214)661-0400, Houston (713)688-1431; **UT.**, Salt Lake City (801)466-8729; **VA.**, Falls Church (703)573-8787; **WA.**, Bellevue (206)454-3400; **WI.**, Milwaukee (414)545-8400; **CANADA**, Montreal, Quebec (514)747-9747, Ottawa, Ontario (613)725-1931, Toronto, Ontario (416)625-0600, Calgary, Alberta (403)276-7567.

CIRCLE NUMBER 16

ories, these devices are expected to provide the density of MOS with the speed of bipolar technology.

In the static area, IBM will reveal how its German research facilities use merged transistor logic (MTL) to develop 16-kbit static memory chips sporting access cycle times of 45/100 ns and power dissipation of just 170 mW. The process used is 2-μm epi-bipolar and the result is a chip area of just over 25,000 mil².

Hitachi's and Toshiba's best CMOS efforts have gone into 2-k × 8 static RAMs. Fabricated with HCMOS, the Hitachi memory uses JFET-powered static RAM cells and operates at a typical access time of 74 ns. When being accessed, the RAM requires just 200 mW of power, which drops to 25 μW during standby. The Toshiba RAM, fabricated with bulk CMOS, uses a coplanar silicon-gate process to get typical access time of 95 ns with a 200-mW power dissipation when active, and just a 1-μW power requirement during standby.

Super-low power standby—150 μW—is Mostek's (Carrollton, TX) contribution to NMOS static RAMs. The company will describe the special circuitry developed for them.

PROMs, EPROMs getting faster

In PROMs and EPROMs, Intel is right on the spot with three developments. One is a 64-kbit UV EPROM that uses a scaled-MOS process to yield 200-ns access and 0.24-μm² cell size. The other two are a 2-k × 8, 35-ns, 600-mW bipolar PROM that has been squeezed onto a 140-mil square chip and a 2-k × 8 electrically erasable nonvolatile memory that uses oxides no thicker than 200 Å to permit electrons to tunnel toward or away from a floating polysilicon gate.

Joining Intel in this discussion, Motorola (Austin, TX) will describe the double-poly HMOS technology used to fabricate its 8-k × 8 unit, which boasts 200-ns access and 150-mW power dissipation. Mostek will tell of a device that while slower—300-ns access—contains such novel features as redundant circuitry for matrix, column decoders, sense amplifiers and input data buffers.

LSI processor circuits will also take a share of the ISSCC spotlight, with several systems on a chip coming to light. Intel will present two papers, one describing a forthcoming math processor and the other describing LSI circuits for its 1-Mbit bubble-memory system.

The math processor combines a four-state, 29,000-bit ROM, nearly 700 bits of RAM and a 68-bit-wide internal data path to provide floating-point multiplication, division, square-root, and transcendental functions on one chip. The LSI chip set, packing bipolar, NMOS, CMOS and power-VMOS chips into a support system, parlays the best features of each technology into a compact system for bubble-memory control.

Silicon-gate CMOS is Fujitsu's tool for developing a 10,000-gate CPU that dissipates a mere 130 mW and offers a 400-ns microinstruction cycle time. Bipolar technology is at the root of NEC-Toshiba's 18-bit register and arithmetic unit (RALU), which has a 7-ns read-modify-write cycle. What's more, with four RALUs cascaded, a 72-bit ALU can be set up to operate at 100 MHz.

Standard NMOS technology is the key to Data General's partitioned computer architecture and a family of circuits for a CPU that performs 16-bit register-to-register operations in a 400-ns microcycle and memory-to-register in just two microcycles. ■■

Want to go?

The 1980 International Solid State Circuits Conference will be held at the San Francisco Hilton on Feb. 13 through Feb. 15. For all the information you'll need on attending the ISSCC, including complete program, conference digest and descriptions of the evening panel sessions, contact Conference Consultant Lewis Winner, 301 Almeria, P.O. Box 343788, Coral Gables, FL 33134. (305) 446-8193.

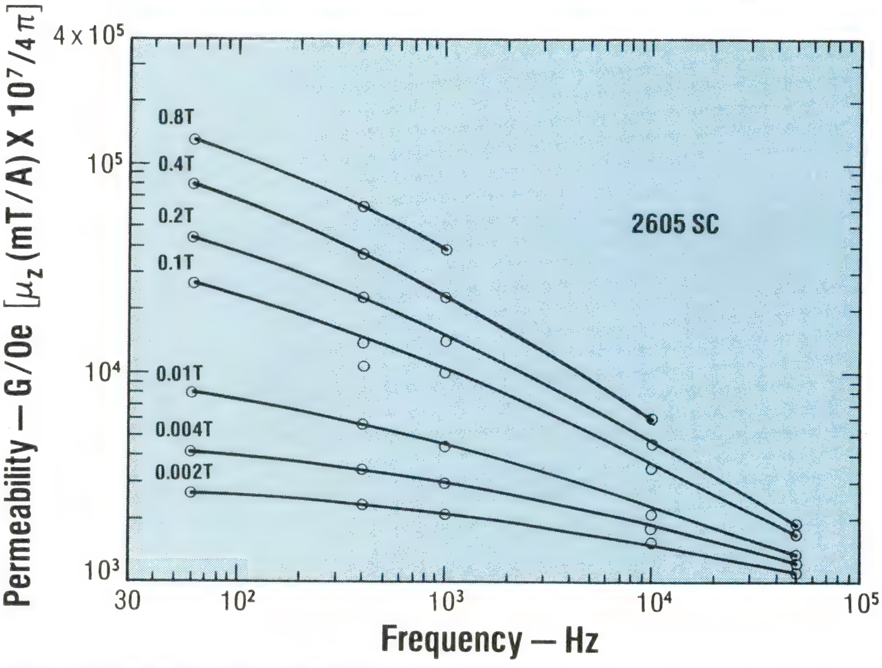
Glass-like metal alloy cuts transformer core losses radically

Aircraft transformers made with Metglas 2605SC, an amorphous metal alloy, exhibit as little as one-third the core loss of similar transformers made with conventional ferrite cores. Test data just released by developer Allied Chemical Corp. (Morristown, NJ) indicate excellent magnetic properties and efficiency when the formulations are used as transformer cores in both power-transfer and power-supply applications.

Metglas 2605SC is a glass-like formulation of iron, with a perfectly random atomic structure formed by rapid cooling—1-million degrees per second. In addition to strong hardness with no grain and high resistance to corrosion, the Metglas formulation has a high magnetic permeability of 8000 G/Oe at 60 Hz and 0.01 tesla induction.

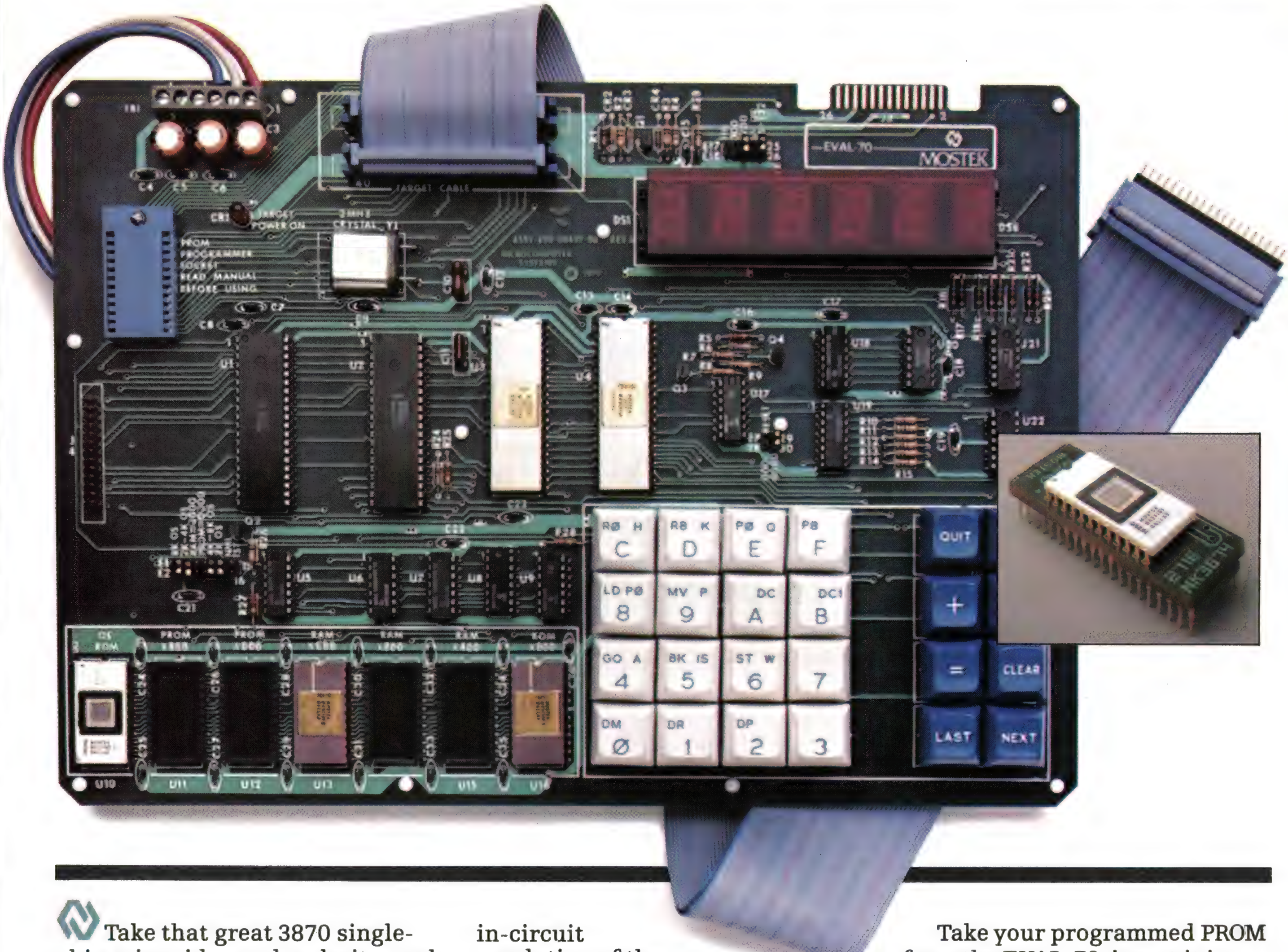
Although this permeability will de-

Stephan Ohr
Components Editor



The permeability of the 2605SC Metglas alloy decreases with the excitation frequency, but remains useful up to 50 kHz.

Field test your 3870 design for under $600.



Take that great 3870 single-chip micro idea and make it a real application. Or set up a one-shot test quickly and economically. The tools for this easy, fast, reliable and easily duplicated design solution: Mostek's EVAL-70™ and the MK3874™.

EVAL-70 is our new single-board microcomputer for program development, debugging and emulation of Mostek's entire 3870 family of single-chip microcomputers.

Write and debug your program in RAM using the powerful DDT-70 operating system. Use the 40-pin emulator cable for real-time, in-circuit emulation of the 3870, 3872 or 3876. Software single step your program for errors. To finish, load the program into a 2716 EPROM using the EVAL-70's on-board PROM programmer.

MK3874 is our piggyback EPROM single-chip microcomputer with the same architectural features, pinouts and I/O lines as other 3870 family members. Using 24-pin EPROMs, the 3874 can address 1K, 2K or 4K bytes of memory, for ideal 3870 family prototyping, testing or low volume production.

Take your programmed PROM from the EVAL-70, insert it in the 3874, put the 3874 in the target socket and field test your idea.

An inexpensive yet powerful combination: the EVAL-70 is $499; an MK3874 without PROM is $92.

See both at your Mostek distributor. Or contact Mostek, 1215 West Crosby Road, Carrollton, Texas 75006; phone 214/323-6000. In Europe, Mostek Brussels; phone 660.69.24.

MOSTEK®

© 1979 Mostek Corp.

CIRCLE NUMBER 17

crease as excitation frequency increases, thus increasing transformer core loss, Metglas ribbons shine in 400-Hz aircraft-transformer applications. Units made of 1-in.-wide ribbons of Metglas 2605SC showed great superiority when compared with standard aircraft transformers built around conventional steel cores. They were comparable in size and weight (0.4366 lb for the steel transformers vs 0.4467 lb for the Metglas units), as well as magnetic flux density (at 115 V, 400 Hz, 11.9 kG for steel vs 11.6 kG for Metglas). Copper weight in coil windings was also very similar—0.1168 lb for the steel units, 0.1149 for the Metglas units.

But there the similarity ends. For the steel units, core loss was 2.41 W—for the Metglas 2605SC units, 0.79 W. What's more, in another experiment geared to 400-Hz aircraft transformer applications, a Metglas transformer charged with 14.8 kG outdid a standard thin transformer charged with 14.68 kG. The tally? A core loss of 0.57 W for Metglas vs 2.7 W for steel, while occupying 82% of the space of a conventional 400-Hz unit.

The Metglas formulation has already been proven even more successful at lower frequencies. A 120-V, 60-Hz transformer made with Metglas ribbons, when compared to a similar steel-core transformer (2.00 × 2.00-in. Metglas core vs $2^{1}/_{4}$ × 1.00-in. steel core, both weighing about $8^{1}/_{2}$ lb), exhibited a core loss of 1.14 W—a far cry from the 8.50 W exhibited by the standard transformer.

Despite increasing figures, Metglas 2605SC formulations show comfortable losses up to 50 kHz, which should also make them useful for some switching-power-supply applications. With an induction of 0.1 tesla, for example, a 2605SC piece excited at 50 kHz will exhibit a core loss of around 10 W/G.

Metglas formulations should prove especially useful for power-transmission lines, Allied Chemical believes. According to data released by MIT's Lincoln Laboratories, a 15-kVA Metglas transformer exhibited 12.5% of the core loss of a conventional 15-kVA transformer, while running 30% cooler—14 W at a temperature of 70 C vs 112 W at 100 C. ▪▪

Universal macroassembler readies for 16-bit onslaught

A cross-assembler that debugs 1000 lines of assembly code in roughly half a minute is holding out a macro solution to the problem of software development for powerful microprocessors.

Programs written in assembly language need a rapid debugging cycle and a macro capability as well, to eliminate much of the repetitive coding. The MAX-11 cross-assembler from System Kontakt Inc. (Bedford, MA) not only zips through assembly code but also lets the user switch fast from one target processor to another.

Based on the PDP-11, the MAX-11 consists of 11 software modules that are directed by a "traffic-cop" main program and, in turn, interact with the host machine's operating system via an executive (see schematic). But only one of the modules, the op-code processor, depends on the target machine; the rest are μP-independent.

While MAX-11 versions for 8-bit chips have served for some time, MAX-11s for the 8086, Z8000, 6800 and LSI-11 are now available, in two versions: one for the single-user RT-11 and the other for the multiuser RSX operating system. MAX-11 can also run under RSTS via the RT-11 emulator, and a UNIX Executive is being developed.

Patterned after DEC's VAX-11 macroassembler, the MAX-11 is a natural for the VAX user. But the system works in the same manner for all target machines.

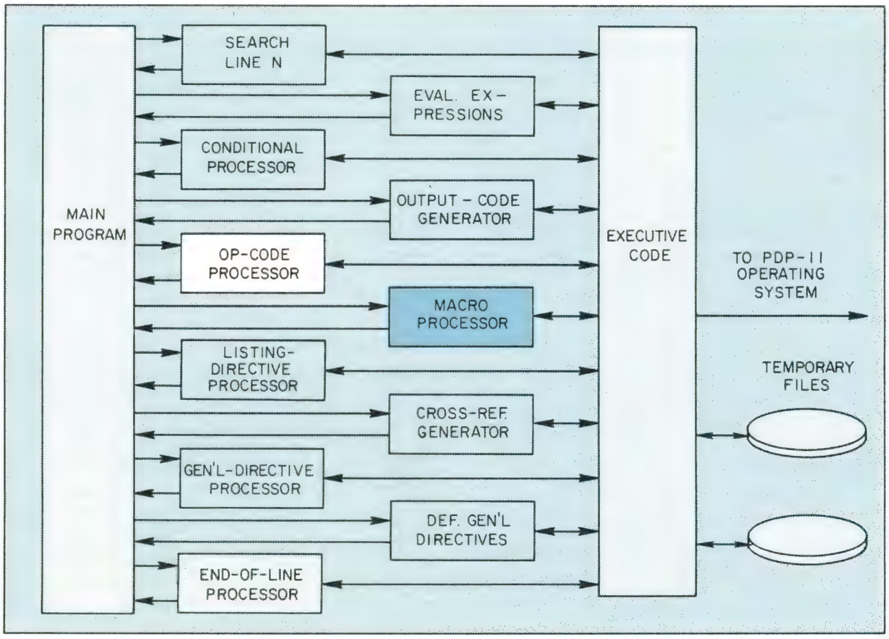
Once code conversion starts, the MAX-11's main program examines one line of source program at a time—evaluating expressions, looking for branching conditions, generating output code and so on. If the line is in assembly language, the op-code processor performs machine code conversion; if a macro is detected, the macro processor breaks it down and writes the corresponding code.

Another group of modules finish the job: a listing-directed processor, a cross-reference processor and a general-directive processor.

Meanwhile the system's executive generates an object code file, a listing file and an error file. The latter is the most important debugging aid; it lists all mistakes found during assembly (including those in macros).

The temporary object-code files created by the executive during assembly can down-load the machine code directly into PROM, through a normal (serial) interface. The MAX-11 also comes with a relocatable assembler that has such features as PSECTS and its attributes. Also, addresses can be allocated separately for (fixed) ROM and (variable) RAM. ▪▪

Max Schindler
Software Editor



MAX-11 comprises 11 modules that interact with the host's operating system. Only the op-code processor depends on the target device.

MOSTEK 3870

Bring home the big one with our single-chip microcomputer.

Now you can bring that microcomputer idea to the surface with Mostek's 3870. Already, hundreds of companies have chosen it for its flexibility, reliability and low cost:

Shakespeare Marine Electronics: "We're using Mostek's 3870 as the controller in our chart printing fish finder, the Ultimate 1™. We incorporated two separate programs in the 3870's 2K ROM memory. This let us introduce a deluxe model—the Ultimate 2™—that uses the same circuit." *Ed Shortridge, Chief Engineer.*

Saxon Business Products, Inc.: "Mostek's 3870 cost-effectively replaced a three-chip microprocessor set. As the controller in the Saxon 301, 302, and soon—the 301R—bond copying machines, the 3870 has improved the Saxon-line reliability with field up-time at all time highs." *Mike Bonavia, Electronic Engineer.*

The point is that our MK3870 is the performance and volume leader in the 8-bit single chip market—we've already shipped over one million of them to customers around the world.

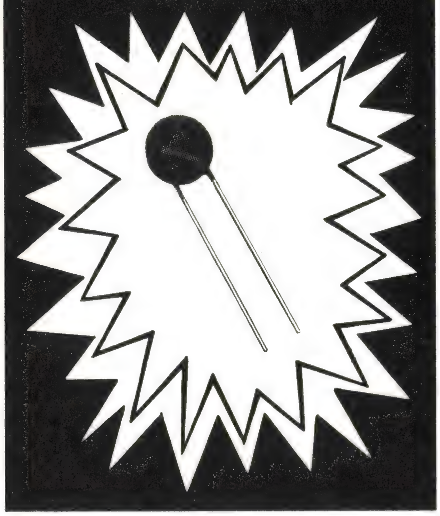
Bring home your big one with our 3870. Call or write Mostek, 1215 West Crosby Road, Carrollton, Texas 75006; phone (214) 242-0444. In Europe, contact Mostek Brussels; phone 660.69.24.

MOSTEK®

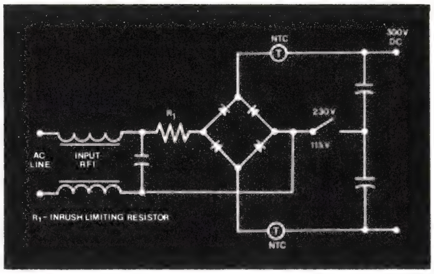
© 1979 Mostek Corp.

Keystone

INRUSH CURRENT LIMITERS

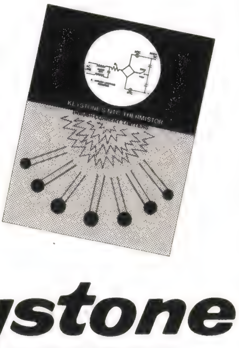


Turn to Keystone to protect your switching power supplies from turn-on surge...as diagramed below.



Keystone has designed special disc-style NTC thermistors with crossed leads in eight types with "cold" resistance values @ 25°C from 0.712 to 120 ohms.

Get the facts
...send for
Bulletin 787
covering
Inrush
Current
Limiters.



Keystone
CARBON COMPANY
Thermistor Division
St. Marys, PA 15857
814/781-1591 • Telex 91-4517
CIRCLE NUMBER 53

Two-chip keyboard makes intelligence a movable choice

A two-chip keyboard design allows a terminal designer to decide where to put the validation and encoding intelligence—in the keyboard or in the terminal. Designed by Key Tronic (Spokane, WA), the keyboard contains one drive and one sense chip, which serve as an interface between a capacitive switch matrix and a microprocessor.

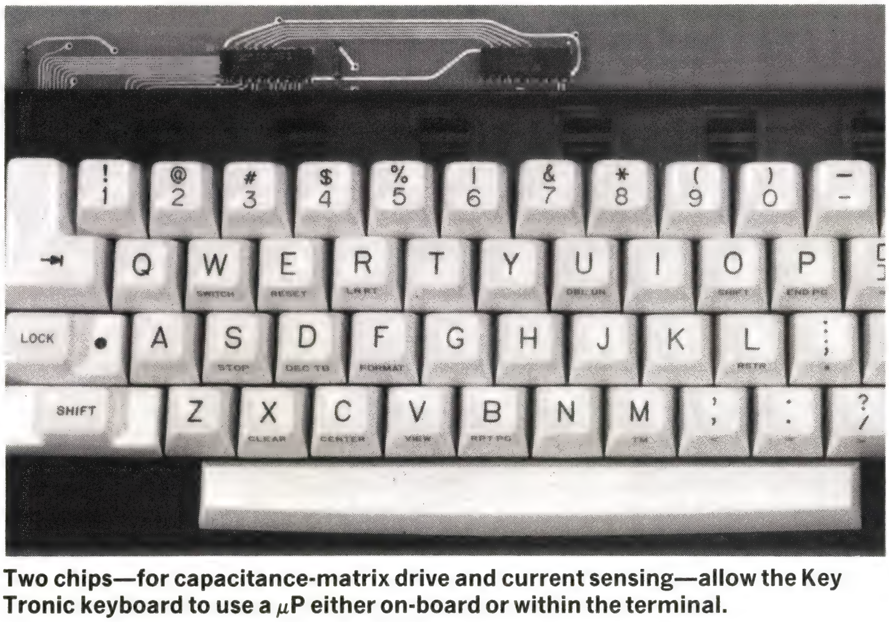
The 20-pin drive chip has four address, one strobe, one latched-output (for hysteresis control), two power and 12 matrix-drive lines. The sense chip contains eight individually latched current-sensing detectors with a common threshold control and an output latch reset line in common with the drive chip's strobe line. The resulting 96-location matrix can be easily doubled by adding another drive chip.

A typical matrix interrogation routine begins by bringing the strobe line low (resetting the eight data latches of the detector chip) and presenting a 4-bit address to the drive chip. Bringing the strobe line high causes the appropriate matrix drive line to be selected and driven. This voltage transition causes a current pulse on every sense line that has a key closed in common with the selected drive line.

The detector chip senses the current pulses and sets the corresponding output latches. The status of eight keys can then be read from the data bus. Loading this information into RAM completes the routine and gives the processor all the information necessary for N-key rollover.

A complete 96-key interrogation routine takes less than 0.5 ms, using an Intel 8048 or similar μP. Even with validation and output subroutines included, the microprocessor uses at most 20% of its time servicing the keyboard. Consequently, the keyboard can be connected directly to a μP in a terminal.

Both sense and drive chips use bipolar technologies. In addition, their matrix-drive and sense lines have been designed to exhibit low impedance to the supply in their normal modes of operation. Although isolation is still required between drive and sense lines (to keep key-up capacitance to a minimum), this low-impedance concept reduces the amount of grounding required.■■



Two chips—for capacitance-matrix drive and current sensing—allow the Key Tronic keyboard to use a μP either on-board or within the terminal.

NOW THERE ARE 7 SIMPSON DMM's
...choose the one that's best for you!

THE LATEST! Model 463, CORDLESS with LCD readout, 200-hour battery operation, 26 ranges, 0.2% DC V accuracy . . . all in a compact package.

$175

All Simpson Digital Multimeters Have

reliable overload-protected LSI circuitry, easy-to-read 3-1/2-digit displays, automatic polarity. 200-hour burn-in backed by a 1-year guarantee. A full line of optional accessories.

For $165

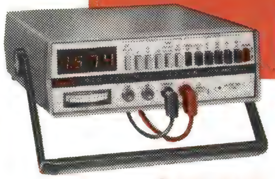
Popular Compact Model 461 with 26 pushbutton ranges, 0.25% DC V accuracy.

For $205

Autoranging Compact Model 462 with batteries, charger/adapter. 0.25% DC V accuracy.

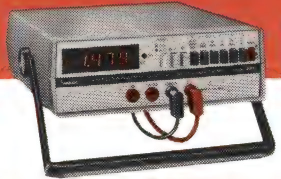
For $325

360-2 Digital VOM with 0.25% DC V accuracy, 28 ranges, low-power ohms, AC/battery operation.



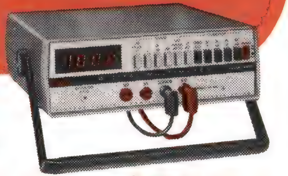
For $335*

Deluxe 460-3A with 0.1% DC V accuracy, 32 ranges, low-power ohms, analog trend display.



For $355*

Autoranging Model 465A with 0.1% DC V accuracy and low-power ohms ranges.



For $255*

Popular Bench Model 464A with 0.1% DC V accuracy and 28 ranges.

***Price for AC line version. AC/battery charging version available for nominal additional cost.**

CHOOSE THE ONE THAT'S BEST FOR YOU.
SEE THEM AT YOUR LOCAL SIMPSON DISTRIBUTOR.

Simpson®
INSTRUMENTS THAT STAY ACCURATE

SIMPSON ELECTRIC COMPANY
853 Dundee Avenue, Elgin, Illinois 60120
(312) 697-2260 • Cable SIMELCO • Telex 72-2416

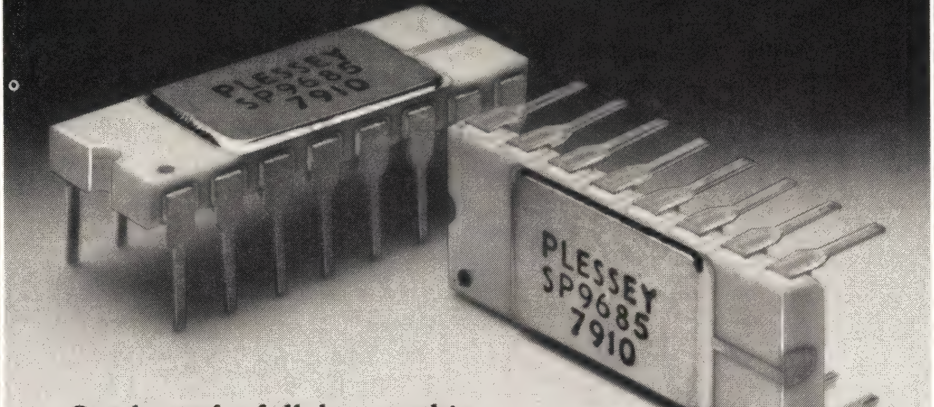
KATY INDUSTRIES
INDUSTRIAL EQUIPMENT GROUP

CIRCLE NUMBER 19

NOW-from Plessey Semiconductors

THE WORLD'S FASTEST COMPARATORS

If you think the comparators you use are fast, we've got news for you. Our SP9685 gives you a new world record for high speed integrated circuit comparators and opens up whole new application areas in nucleonics and instrumentation. The propagation delay is only 3nS – that's less than the time it takes for light to travel a metre! It's twice as fast as the AM685 – and it's available NOW.



Send now for full data on this brilliant new breakthrough from Plessey Semiconductors.

PLESSEY Semiconductors

Plessey Semiconductors Limited
Cheney Manor, Swindon, Wiltshire SN2 2QW, UK.
Telephone: 0793-36251 Telex: 449637.
1641 Kaiser Avenue, Irvine, California 92714 USA.
Telephone: 714 540 9979 Twx: 910 595 1930

Main European Sales Offices
Belgium, Tel: Brussels 02 733 9730 Telex: 22100. **France,** Tel: Paris 776 43 34 Telex: 620789.
Italy, Tel: Milan 345 2081 Telex: 331347. **Sweden,** Tel: Stockholm 08 235540 Telex: 10558.
West Germany, Tel: Munich 089/23 62-1 Telex: 5-215322.

CIRCLE NUMBER 106

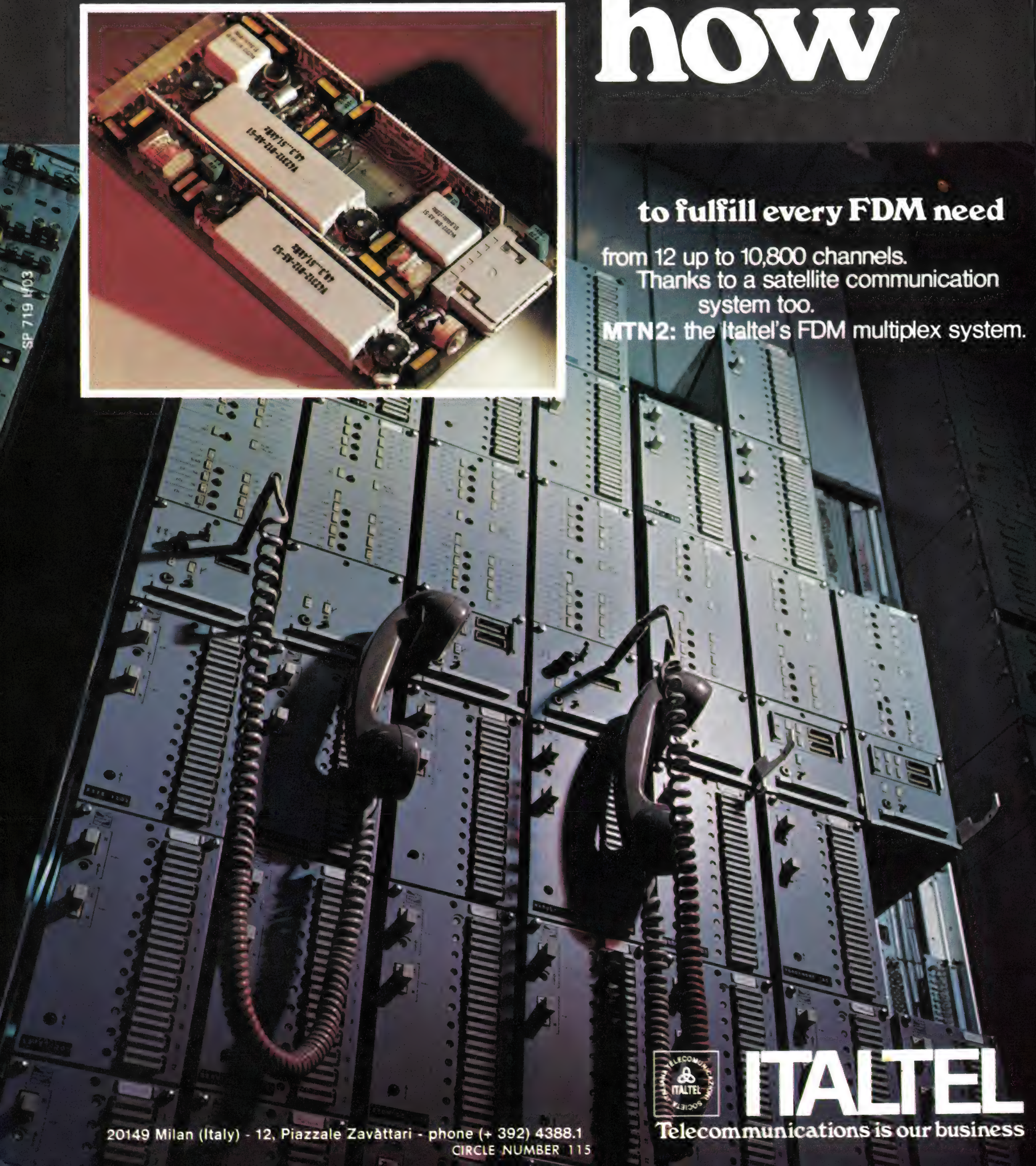
Electronic Design
INTERNATIONAL
February 1, 1980

Data-comm MUX and concentrator have brains

Single-board μCs perform big in little packages

Aluminum electrolytic capacitors—toughest yet?

Digital thermometers output BCD and analog



We know how

to fulfill every FDM need

from 12 up to 10,800 channels.
Thanks to a satellite communication system too.
MTN2: the Italtel's FDM multiplex system.

ITALTEL
Telecommunications is our business

20149 Milan (Italy) - 12, Piazzale Zavàttari - phone (+ 392) 4388.1
CIRCLE NUMBER 115

Data-comm MUX and concentrator with a difference—brains

Tectran Corporation Pty., 83 York Street, Sydney, New South Wales, Australia 2000.

Microprocessors make the Comdata 500 an intelligent statistical multiplexer and the Comdata 600 a programmable data concentrator. Based on 8085A μPs, both offer a wide range of capabilities.

The Comdata 500 uses a proprietary link protocol and can service up to 16 terminals. It provides better-than-200% multiplexing efficiency over short periods while maintaining complete, asynchronous communications transparency.

The Comdata 600 uses two microprocessors and provides programmable concentration of various streams of data. Offering four to 16 ports, it can support a mixture of lines, speeds, protocols, high-speed routing, and multidrop and intercomputer communications. This versatility allows network monitoring and logging, dynamic reconfiguration, data capture and protocol conversion.

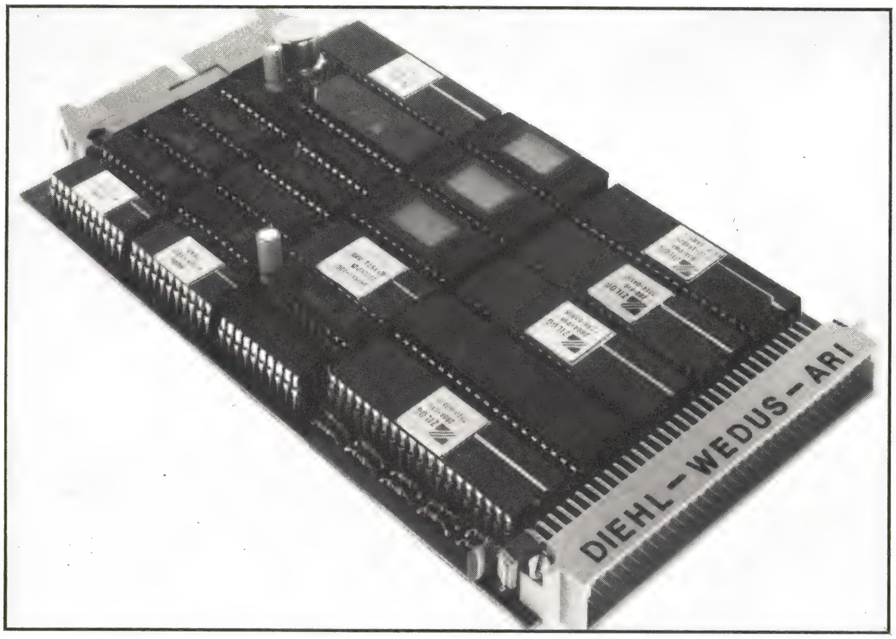
Both the 500 and 600 have comprehensive on-board self-diagnostics, modular construction and a four-character systems display to provide operator communications. Terminal port characteristics can be factory-set, loaded or altered on-site, and down-line loaded.

There are no doors or arrays of coded switches; and operation doesn't require removal of any covers. Controls have been kept to a minimum.

All Comdata products have been designed for easy access as well as for simple insertion and removal of printed-circuit boards. To optimize field maintainability, all models are designed for Hewlett-Packard signature analysis.

CIRCLE NO. 501

Single-board μCs are big performers in little packages



Diehl GmbH and Co., Stephanstrasse 49, D-8500 Nuremberg, Federal Republic of Germany. (0911) 475-2643. Telex: 0622591.

The Wedus family of single-board microcomputers packs a Z80 CPU plus considerable arithmetic and I/O capability and increased memory space onto small, standard Eurocards.

In fact, the newest—and highest-performance—member, the Wedus-ARI, reportedly offers a new dimension in performance/size ratio. With an Am9511 arithmetic processor providing additional power for numeral computations, the Wedus-ARI performs both fixed and floating-point arithmetic and allows a wide range of floating-point trigonometric and mathematical operations.

On one Eurocard, the Wedus-ARI contains not only an 8-bit Z80 CPU but also three parallel-I/O interface modules, one counter/timer circuit, one serial-I/O circuit, one direct-memory-access chip, an Am9511 arithmetic processor, 12 kbytes of EPROM and 2 kbytes of RAM.

The Wedus-PCS offers greater I/O capability and more memory space than simple μCs. Besides the Z80, the Eurocard board contains five parallel-I/O interface modules (Z80-PIOs), one counter/timer circuit (Z80-CTC), one serial-I/O circuit (Z80-SIO), 8 kbytes of EPROM space and 1 kbyte of RAM.

CIRCLE NO. 502

Aluminum electrolytics—toughest capacitors yet?

ITT Components Group, Standard Telephone and Cables Ltd., Edinburgh Way, Harlow, Essex, England. Harlow (0279) 26811. Telex: 81146.

The KS10A series could well be the most advanced Type-I aluminum electrolytic capacitors available. The capacitors are fully approved to BS9078 F0009, a specification as stringent or even more so than BS9078 N002.

Capacitance extends from 68 to 330,000 μF, working voltage to 450 V. This wide range of capacitances and working voltages, coupled with the extended temperature range, means that engineers can now use standard devices instead of being forced to accept lower-grade, nonapproved parts or expensive custom capacitors.

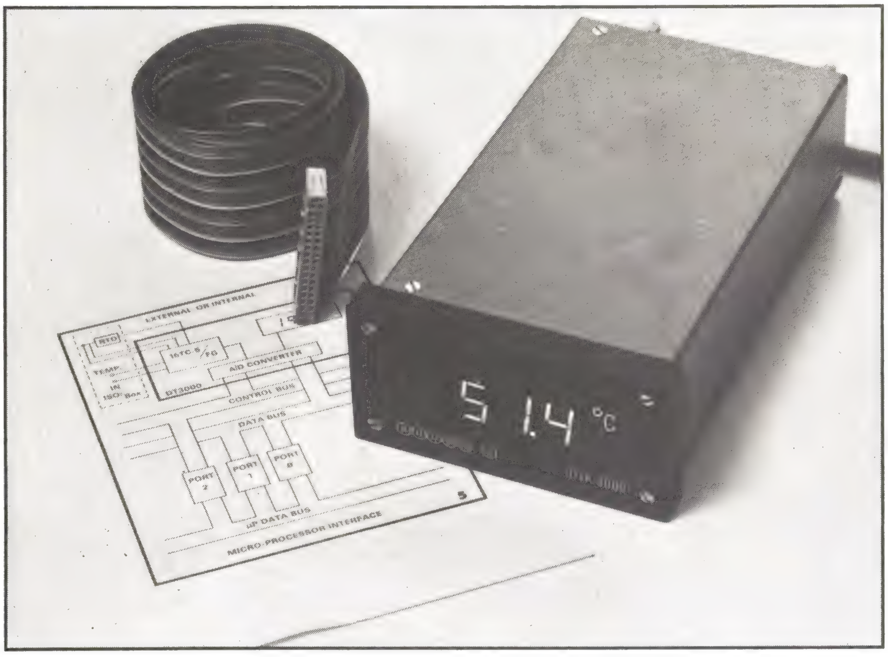
The KS10A capacitors have been tested—with full ripple current applied—at a rated temperature of 85 C for over 2000 hours. The results are impressive: Capacitance changes by no more than 15%, tan δ remains within 1.3 times the initial limit, and dc leakage remains within its limit.

There are 14 Type-I capacitors in the KS10A series, with voltage ratings ranging from 6.3 to 450 V dc. Less than or equal to 25 V dc, the standard selection tolerance is −20 to +80%. Above 25 V dc, it is −10 to +50%.

In addition, an "all-welded" construction meets British Post Office requirements and contributes to a minimum life expectancy of 10,000 hours. Moreover, the insulation withstands as much as 1000 V applied between the insulation sleeve and terminations. The KS10A range is designed to be dimensionally compatible with existing packages for Type I and Type II aluminum electrolytic capacitors.

CIRCLE NO. 503

Digital thermometers output BCD and analog



Ancom Ltd., Devonshire St., Cheltenham, Gloucestershire, GL50 3LT, England. (0242) 513861.

Digital thermometers in the 3000 series offer not only a wide choice of input sensors and differential inputs but also versions with both BCD-digital outputs and analog outputs.

Two reading ranges provide total excursions of ±199.9 or ±1999, with resolutions of 0.1 or 1, respectively. Absolute reading accuracy depends on the type of sensor used. A high-intensity, 14-mm LED display allows daylight viewing.

The 3000 series can work with all popular temperature sensors, including thermocouples (with platinum-resistor auto-cold-junction), platinum resistance sensors, thermistors and semiconductors. A user-programmable linearizer is also available to allow custom setting for unique sensor inputs. An accuracy of ±0.1° can be attained with the platinum resistance sensor, and a Chromel/Constantan thermocouple gives an accuracy of ±1°.

Designed for stable operation, the thermometers feature a repeatability error of just ±1 digit and a maximum temperature drift of 0.025 C/°C with thermocouple sensors and 0.01 C/°C with platinum resistors.

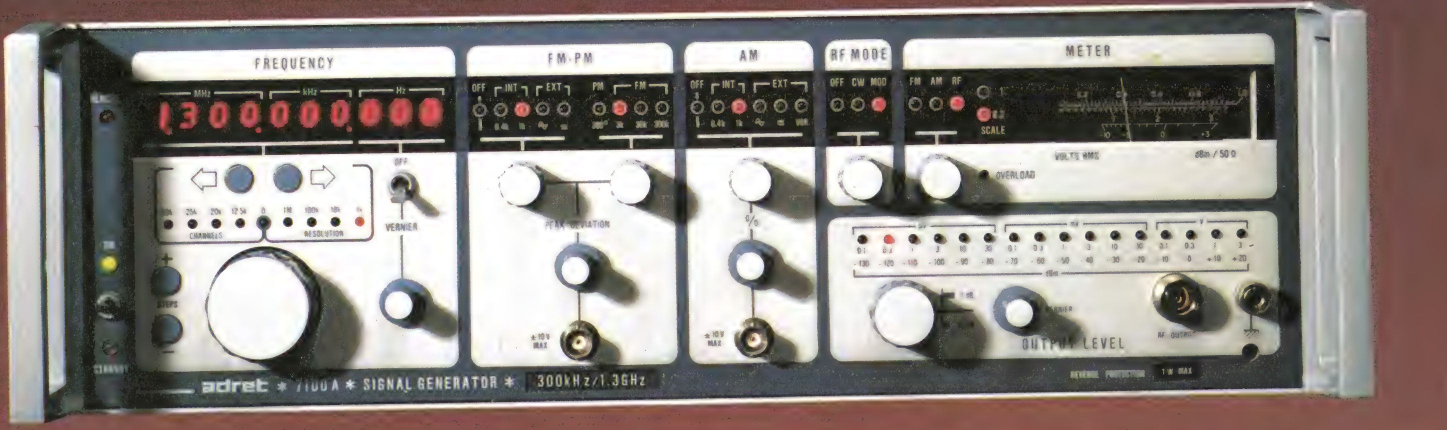
The binary-coded-decimal digital output is parallel and includes all necessary handshaking to allow direct interfacing with microprocessors, data-acquisition systems and printers. Output logic is three-state, so instruments can be bused on a single data highway. Data are outputted on a multipin connector. The CMOS/TTL-compatible outputs can drive four TTL loads.

The analog outputs are conditioned to mV/°C. Also available are versions with voltage-signal inputs instead of temperature-sensor inputs. With this option, the full-scale signal input can be 2 V, 200 mV, 2 mV or 200 μV, which allows the instruments to function as millivoltmeters or microvoltmeters.

The thermometers have a consistent DIN standard housing with a panel cutout of 44 × 92 mm, and are secured with a front-access screw clamp. Standard units are powered by 115/230 V ac, 50/60 Hz.

CIRCLE NO. 504

THE NEW GENERATOR ADRET 1300 MHz SERIES 7100 B



AUTOMATIC OR MANUAL SAME CAPABILITIES

No matter the user you are, of generator or synthesizer, the 7100 B, meeting point of both of these techniques, suits you.
Built in an automatic system, or in a manual set-up, its microprocessor eases its operation without sacrifying any of its outstanding performances.

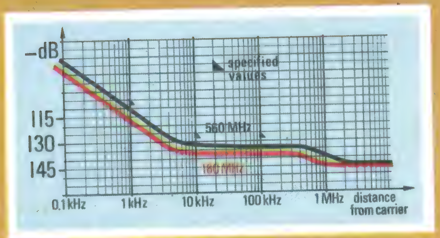
ONE RANGE ONLY, 0.1 THROUGH 650 OR 0.1/1300 MHz

You cover the entire frequency range without any sub-range switching, the frequency setting being either achieved in a pseudo-continuous mode-by a coding spin wheel, or by discrete standard frequency steps of 12,5 - 20 - 25 - 50 and 100 kHz.

The delivered frequency is in direct relation with the stability and accuracy of the built-in quartz crystal time base (5.10^{-9}/24 h) and the maximal resolution as high as 1 Hz with a vernier.

NOISE FLOOR 145 dB/Hz at 600 MHz.

Equally as performing as the best cavity generators (130 dB/Hz at 10 kHz), the 7100 B also provides a spectral purity at 1 kHz from the carrier (115 dB/Hz) to the carrier, close to that of an iterative synthesizer.



Harmonics at – 30 dB and spurious at – 100 dB added to its outstanding spectral purity makes it the ideal instrument for the most difficult tests on VHF and UHF receivers.

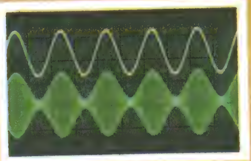
A 160 dB DYNAMIC OUTPUT

You adjust the output level from + 20 dBm to – 140 dBm/50 Ω by one single control, providing simultaneously two resolutions 1 dB and 10 dB by a mere push, while directly reading the 1 dB steps on an autoranging galvanometer.

The output level accuracy specified at ± 3 dB takes into account of all errors, attenuator, flatness, etc. within the range 1/650 MHz. The output stage is optionally protected either by a fast melting fuse or an automatic breaker, and the RF leakage is less than 3 μV.

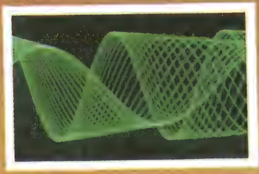
CALIBRATED AM-FM-ΦM MODULATIONS

Simultaneous AM + FM or AM+ΦM can be achieved either by internal 400 Hz or 1 kHz source or by an external signal from DC to 150 kHz (AC or DC coupling).



The AM modulation has a VOR/ILS capability for radionavigation mesurement.

The FM modulation with a deviation of up to 300 kHz makes possible FSK modulation, the pseudo-carrier being always referred to the crystal time base.



The ΦM modulation can be also performed from DC to 50 kHz.

All modulation characteristics, deviation in FM and ΦM and depth in AM are easily read on an autoranging galvanometer (2 sub-ranges).

ALL THESE FUNCTIONS ARE IEEE 488 PROGRAMMABLE

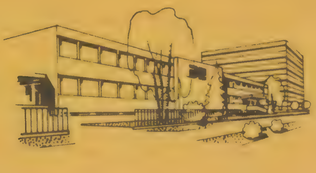
All these performances make it a true reliable and dependable generator in local mode, and much more than a synthesizer when programmed.

Adaptable on all systems using the IEEE 488 bus, its remote operation using a clear and understandable language is really easy, even-though you are not familiar with this technique. With all these VHF/UHF performances, it turns out the chores of manual tests so far performed, into a fast and easy automatic procedure.

A COMPLETE INSTRUMENT

Eight options extend the capability of your generator 7100 B by precisely tailoring it to your exact needs :

- Output protection by fuse or automatic breaker
- Frequency doubler (1.3 GHz)
- IEEE bus programming of all functions
- Frequency extension down to 100 kHz
- 400 Hz line frequency

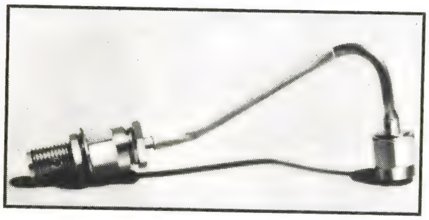


ADRET ELECTRONIQUE FRANCE
12, avenue Vladimir Komarov • BP 33 78192 Trappes Cedex • France • Tél. 051.29.72 •
Télex ADREL 697821 F • Siret 679805077 - 00014 • CCP Paris 21 797 04 •

adret
electronique

CIRCLE NUMBER 116

SMA cable assemblies save you money



Sealectro Ltd., Walton Road, Farlington, Portsmouth, Hampshire, England. Cosham 72211. Telex: 86142.

Completely assembled, semi-rigid cable assemblies, terminated with SMA connectors, are now available for use at frequencies up to 18 GHz. These formed links eliminate wasted and spoiled connectors and cable, and assure the customer of a fixed cost for his production run. At microwave frequencies, the connector-and-cable assembly becomes a component in its own right—for which the performance parameters must be accurately measured and controlled. The necessary specialized manufacturing capabilities are not usually available at the customer's plant. Automated cable forming and trimming, high-speed induction soldering and skilled inspection ensure that these assembled cables will meet specified electrical and mechanical parameters. Guaranteed performance figures can include VSWR return loss, insertion loss, phase angle and vibration. Cables are available and either 0.141 or 0.085 in., semi-rigid cable, and they can be terminated with any straight or right-angled connectors from Sealectro's SRM-SMA range.

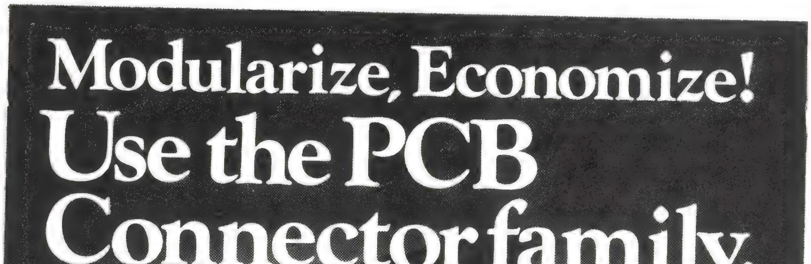
CIRCLE NO. 526

Digital pH meter measures voltage and temperature

Channel Electronics Ltd., P.O. Box 58, Seaford, Sussex BN25 3JE, England. Seaford (0323) 894961.

The Model 6030 pH meter measures millivolts and temperature—in addition to pH. Readout is provided on large and bright gas-discharge displays. The unit measures over the full range of 0 to 14 pH, with a resolution of 0.01 pH. Temperature compensation is fully automatic over the range 0 to 100 C. In the temperature-measurement mode, the instrument measures from −149.9 to 199.9 C with a resolution of 0.1 C. An accurate platinum-resistance probe is used for the temperature measurements. In the voltage mode, the instrument measures over the range ±999 mV with a resolution of 1 mV. For each of the measuring modes, a voltage output from the rear of the instrument delivers 1 mV for each least-significant digit of the display. The 6030 is supplied complete with a gel-filled combination pH electrode, a platinum-resistance temperature probe, and buffer powders. A convenient electrode holder clamps to the front of the instrument. Front-panel controls include a multi-turn buffer control for high-resolution setting, and a recessed slope-correction control.

CIRCLE NO. 527



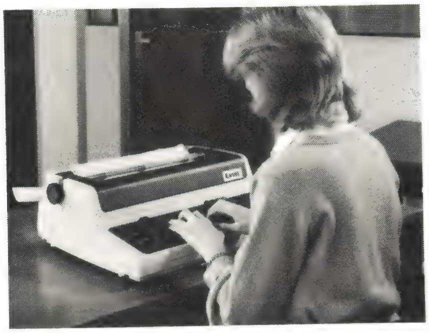
The full range of inversed European connectors is part of the great family of Ericsson modularized telecomponents. The 8–64 point male and female connectors for back plane, rear or front edge connection to PCBs feature selective gold plating on contact surfaces. This plus Ericsson's big series production, keeps our prices down. Connector forks are extra long, insuring greater reliability and reduced plug-in frequency error. We offer a complete line of 2-pole power supply connectors, locking devices, covers for plugs and other accessories. The connectors are part of a modular system with PCB components, electronic shelves, cabinets and a total range of other modular parts.

**LM ERICSSON
TELEMATERIEL AB**
Components Department
Box 401, S-135 24 Tyresö, Sweden
Telex 109 20 LMSBO S

We are a major supplier of components for the industrial market. We belong to the Ericsson Group, one of the world's leading telecommunications manufacturers.

CIRCLE NUMBER 117

Small desktop teleprinter offers powerful features

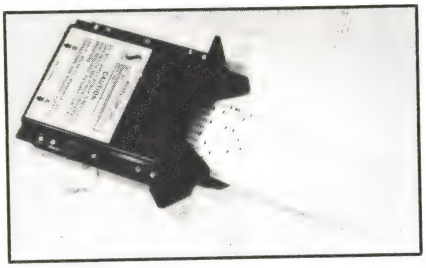


The Exchange Telegraph Co. (Extel), 73/75 Scrutton St., London EC2A 4PB, England. (01) 739-2041.

Now available in the UK, the LA34 DECwriter IV is a small, but powerful, desktop teleprinter terminal. It provides 300-baud (30 char/s) communication and features quiet operation. The 9 × 7 dot-matrix impact printer produces the full upper-and-lower-case, 128-character ASCII set. Character width ranges from 10 char/in. to 16.5 char/in. Vertical spacing is also adjustable—from 6 lines/in. to 12 lines/in. Single-sheet or roll-feed paper can be used. Available paper-tape and disk-storage units enhance the terminal's data-capture, storage, preparation and editing facilities, as well as allowing on-line transmission.

CIRCLE NO. 505

Optical card reader looks at 22 columns



Sealectro Ltd., Walton Rd., Farlington, Portsmouth, Hampshire, England. Cosham 73211. Telex: 86141

A modified solid-state card reader, DSR 100, reads 22 columns of a standard 12-row, 80-column computer card. A 12-row parallel output from an IR-LED/phototransistor device is generated as a card is inserted manually. Cards are returned by spring pressure. Average reading time is 2 s. The open-collector sensor outputs interface directly with low-impedance TTL or high-impedance CMOS logic. Each column optically generates a strobe pulse even in the absence of punched data. Dimensions of the reader are 6 × 1.5 × 5.5 in. Weight is 12 oz.

CIRCLE NO. 506

In-circuit emulator eases system development

GEC Semiconductors Ltd., East Lane, Wembley, Middlesex HA9 7PP, England. (01) 904-9303. Telex: 28817.

The ICE-49 module provides in-circuit emulation for all systems using microcomputers in the Intel MCS-48 family (which includes the 8049, 8048, 8748, 8039, 8035 and 8021). The ICE technique overcomes problems caused by the connection of test equipment which alter the operating characteristics of the system and thus distort the measurements. With the ICE technique, events are monitored in real time and results are stored for later analysis to indicate system operation. Using ICE-49, the designer can prototype software either continuously or in a single-step mode. Break points allow the user to stop emulation upon detection of a wide variety of conditions within the system. A trace capability allows a detailed history of the program execution prior to the break to be examined. The ICE-49 consists of two circuit boards, which reside within the Intellec microcomputer developement system. A designer can use ICE-49 to examine and alter MCS-48 registers, memory and flag values, and to examine pin and port values in a real-time environment. Therefore, use of ICE-49 allows faster and easier development of a microcomputer system.

CIRCLE NO. 507

Universal switching system streamlines the test bench

Racal-Dana Instruments Ltd., Duke Street, Windsor, Berkshire SL4 1 SB, England. Telex: 847936.

A microprocessor-based unit, the Series 1200 universal switching system, provides a flexible and inexpensive means of combining programmable test equipment to form a universal system. The ease with which different test systems can be reconfigured makes the unit an ideal solution to the changing test problems encountered in small batch production of electronic equipment. Based on a 6802 microprocessor, the system uses the IEEE 488 bus. The series 1200 system is built around a Model-1202 mainframe into which five—from a range of six—switching modules may be assembled. The 1202 provides bus interface, built-in diagnostics, self-test, and master control of switching modules. Two of the six switching modules, 1213 and 1214, are designed to switch precise dc and ac voltages and currents, such as the inputs to digital multimeters or the outputs from reference sources. The 1212 module provides power switching for the outputs of dc power supplies or for ac lines. Rf signals are switched by the 1215 or 1216—with the latter module handling signals up to 18 GHz. The sixth module, the 1211, is a general-purpose TTL switching unit.

CIRCLE NO. 508

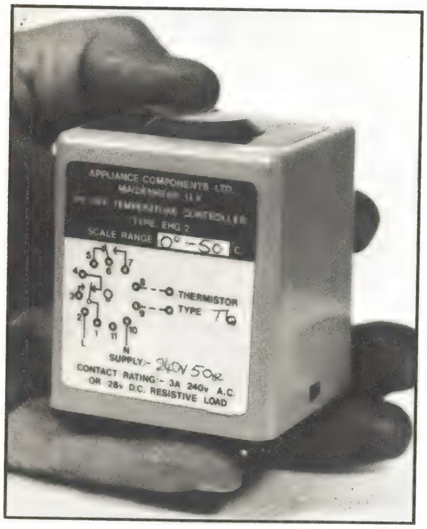
Pneumatic transducer speeds testing of radios

Rohde & Schwarz GmbH, Mühldorfstrasse 15, Postfach 801469, D-8000 München 80, Federal Republic of Germany. (089) 412-92625. Telex: 523703.

An electropneumatic control unit, PIF, actuates pushbutton switches and rotates controls to allow automated testing of car radios and other electronic equipment. The transducer has a BCD interface, but, with a type-PCW code converter, it can also be used in IEC-bus systems. With very simple instructions, testing can be controlled by a desktop computer, such as the Tektronix 4051. The pushbutton actuators are driven by compressed air; the rotary controls are driven by dc motors. Air pressure required is between 4 and 8 atm.

CIRCLE NO. 509

Low-cost temp controllers use thermistor sensors



Appliance Components Ltd., Cordwallis St., Maidenhead, Berks. SL6 7BQ, England. Maidenhead (0628) 72121.

A low-cost family of temperature controllers, type EHG, use a thermistor as the detecting element. The two-step controllers operate from 230 V ac and have internal relays to provide double-pole switching at 3 A when a measured temperature falls below a set value. Normally, the relay contacts close at the switching points, but models are available with the reverse switching arrangement. Five basic models cover the following temperature ranges: −30 to +10 C, 0 to +50 C, +20 to +80 C, +50 to +115 C and +150 to +250 C. A flying-lead version (EHG1) has dimensions of 59 mm (H) × 39 mm (D) × 70 mm (width including mounting flange). An 11-pin plug-in version (EHG2) is 62 × 51 × 51 mm.

CIRCLE NO. 510

Add-on unit converts meter to set-point control

Sharetree Ltd., Parametrol Div., 70 Westward Rd., Stroud, Gloucestershire, England. (04536) 2006

A compact module, the Watchmeter, turns an analog meter into a set-point controller, signalling whenever reading goes outside a pair of easily preset limits. The unit can be used to automate almost any voltage-monitored system. Weight is 1.6 lb; dimensions, 6 × 3 × 8 in. It can be used panel-mounted or free-standing. LEDs give immediate indication of any deviation, and, at the same time, relays are energized to switch 3 A at 250 V for audible alarm, automatic process shutdown or other control functions. An integral memory allows operation in a mode where the LED remains lit, and the relay energized, after the meter returns to a reading within the limits. In this mode, the memory circuits are cleared and reset by operating switches. Control accuracy is ±1%, regardless of meter accuracy.

CIRCLE NO. 511

Keyboard/printer terminal has code converter

Data Dynamics, Data House, Springfield Rd., Hayes, Middlesex, England. (01) 848-9781. Telex: 935429

A new keyboard/printer in the ZIP line includes a built-in code converter. The converter allows a terminal to communicate in an 8-level code and to read or punch either 5-level or 8-level paper tapes. One application for this terminal would be to produce paper tapes for a Telex system using an in-house computer as a word processor and editor. Alternatively, the terminal could store incoming Telex messages on disk or magnetic tape—by reading the Telex machine's 5-level tape and delivering 8-level code to the computer system. The keyboard/printer uses a 5 × 7 dot-matrix print head. It employs standard Telex roll paper. Versions for sprocket-fed paper are available.

CIRCLE NO. 512

Switching-regulator units power μP systems

Amplicon Electronics Ltd., Lion Mews, Hove East Sussex BN3 5RA, England. Brighton (0273) 720716. Telex: 877470 AMPCON.

Four new switching power supplies in the RT range are designed for microprocessor applications. In addition to their main 5-V outputs, they have isolated auxiliary outputs of 5 and 12 V (RT 153 and RT 303) or 5 and 15 V (RT 154 and RT 304). Two of the units (RT 303 and 304) supply 60 A from the main 5-V output, while the other two supply 30 A. The auxiliary 5-V output delivers 5 A (RT 303 and 304) or 2 A. All 12-V outputs are 5 A, and 15-V outputs are 4 A. Dimensions are 5 × 5.5 × 9.5 in. (RT 153 and 154) and 5 × 8 × 10 in. (RT 303 and 304). Combined total power ratings are 150 W and 300 W, respectively.

CIRCLE NO. 513

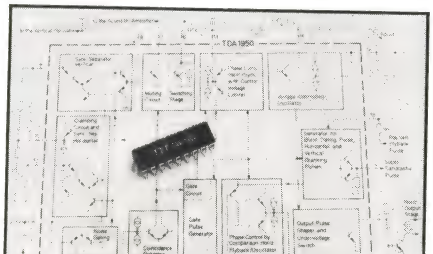
Low-cost evaluation kits get you into fiber optics

Burr-Brown International Ltd., Cassiobury House, 11-19 Station Rd., Watford, Herts. WD1 1EA, England. Watford (0923) 33837. Telex: 922481.

Two fiber-optic data-link kits, FODL-K1 and FODL-K2, are now available for only £68.35 and £86.25, respectively. Both units are available from stock. Each kit contains all components needed to set up a prototype data link. The FODL-K1 includes 20 ft of fiber-optic cable and has a data transmission speed of 25 kbaud. The FODL-K2, supplied with 6 ft of cable, allows communication at 250 kbaud. All transmitters and receivers are housed in metal packages, 42 × 77 × 17 mm, which provide noise immunity in an industrial environment. Of course, the fiber-optic cable has inherent noise immunity.

CIRCLE NO. 514

Bipolar IC provides TV line oscillation and sync

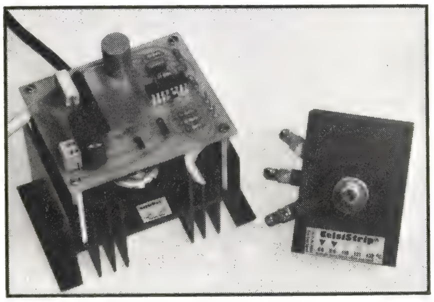


ITT Semiconductors, Maidstone Rd., Footscray, Sidcup, Kent DA14 5HT, England. Telex: 21836.

A bipolar integrated circuit, TDA 1950, provides all the stages needed for sync separation and line synchronization in TV receivers. The number of external components required is very small. The circuit is an advanced version of the well-known TBA-950 and TDA-9500 line oscillators. Separation of line and frame pulses is carried out in two separate stages. Blanking and peak rate of the sync pulse are measured by a clamping circuit, so that the separation level is determined by the sync signal. Pin 5 can be grounded to use the circuit for video recording.

CIRCLE NO. 515

Low-cost adhesive spots record temperatures



Spirig Industries, CH-8640 Rapperswil, P.O. Box 160, Switzerland.

A range of adhesive strips provides a low-cost way to record surface temperatures of electronic equipment. A sensitive triangle turns black when its rated temperature is exceeded for a fraction of a second during its application history. It then stays black permanently. Thus, a strip with triangles for a range of temperatures can record the peak temperature of equipment. Ratings are available from 40 to 260 C (105 to 550 F). The large-quantity price is 9 cents.

CIRCLE NO. 516

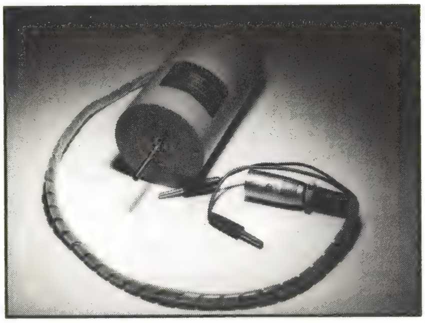
Run ANSI COBOL on LSI-11 μC

Micro Focus Ltd., 58 Acacia Rd., St. John's Wood, London NW8 6AG, England. (01) 722-8843. Telex: 28536.

A full CIS Cobol software package for the LSI-11 series allows ANSI-standard Cobol programs to be developed and executed under the RT-11 operating system. The minimum LSI-11 configuration needed to compile and run Cobol programs is 28 kwords. CIS Cobol is delivered to LSI-11 users in ready-to-run form on a standard 8-in. diskette. In addition to floppy disk, the new software supports other devices, including VT 52 and VT 100 CRTs and the LA-36 DECwriter terminal. CIS Cobol compilers already exist for the PDP-11 series and for the Intel 8080 and Zilog Z80 micros.

CIRCLE NO. 517

Brushless dc motor has built-in speed control



Walter Jones and Company (Engineers) Ltd., Charlton Works, Newlands Park, Sydenham, London SE26 5NG, England.

A brushless dc motor has built-in speed-control circuitry. With a length of just over 5 in., and a diameter of 2-1/2 in., the motor has a rated output of approximately 7 W and a nominal speed range of 10:1. Rotation is reversible even under load. The speed/torque characteristic is a straight line from no-load to starting torque. The slope of the characteristic can be selected to satisfy specific requirements. Depending on the applied load torque, the speed can be continuously variable or in predetermined steps over the nominal speed range. Speed-control accuracy is better than ±1% and is independent of load-torque variations within the motor's range. Accuracy is also independent of input voltage over a range of ±20%. The speed range of the standard model is from 500 to 5000 rpm. Other stepless or stepped ranges are available.

CIRCLE NO. 518

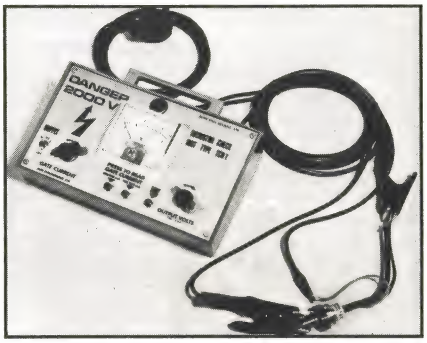
Transmit pressure data with a solid-state sensor

N.V. Philips Gloeilampenfabrieken, Science and Industry Div., P.O. Box 523, 5600 AM Eindhoven, The Netherlands. (040) 784616. Telex: 51573.

A solid-state pressure transmitter offers significant advantages over conventional pressure-measurement systems. Based on a silicon-chip transducer in a Wheatstone bridge configuration, the device employs a piezoresistive effect. Because it directly converts pressure into an electrical signal, it avoids mechanical transmission problems such as hysteresis and susceptibility to vibration. The bridge arrangement gives high sensitivity even with minimal displacement. For example, a 1-μm deflection generates an output of 50 mV. This sensitivity allows the chip to be protected with a diaphragm for operation in corrosive environments. Because of its inherent simplicity, the device is cost-competitive with alternative pressure-measurement systems. Versions are available with pressure spans from 0 to 0.25 and from 0 to 160 bar. The output is 4 to 20 mA, with a linearity error of less than 0.5%.

CIRCLE NO. 519

Portable unit checks thyristors, triacs, diodes

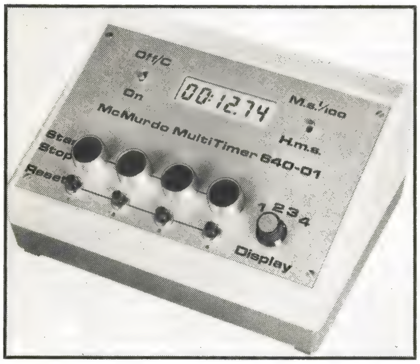


Alan Steel Designs Ltd., Paris House, Market Square, Rugeley, Staffordshire WS15 2BJ, England. Rugeley (08894) 2162.

A portable unit, TCU-1, allows nondestructive testing of thryistors, diodes and triacs. Three output leads, fitted with crocodile clips, connect to the anode, cathode and gate of the device to be tested. Adjustable high-voltage pulses then check the forward and reverse breakdown characterisitics of the devices. An adjustable gate-current circuit checks minimum firing current. The lightweight unit is specifically designed for in-situ testing of suspect thyristors and other devices. It operates from 240 or 115 V ac, single phase, at 50 or 60 Hz. A built-in meter monitors breakdown voltage and firing current.

CIRCLE NO. 520

Stopwatch times four events simultaneously

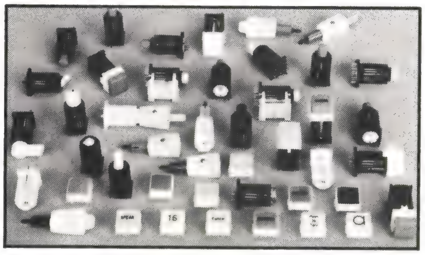


McMurdo, Rodney Rd., Portsmouth, Hampshire PO4 8SG, England. Portsmouth (0705) 735361.

The MultiTimer 640-01 combines four stopwatches in a single compact instrument. Thus, four completely independent time events can be recorded. Each stopwatch has an accuracy of 99.999% over the temperature range of −5 to +45 C. Timing accuracy is achieved by use of a quartz crystal. Stopwatches can be operated independently either by local or remote control. Time measurements can be carried out over 100 h to a resolution of 0.01 s. Timings are displayed on a 6-digit, 12.5-mm, LCD. A switch is included to select any of the four stopwatch outputs for individual display. The compact instrument weighs only 850 g, including the self-contained 9-V battery. The instrument can also be operated from an external 9 to 12-V dc supply.

CIRCLE NO. 521

Pushbutton switches mount on PC boards



Zettler GmbH, Postfach 202626, D-8000 München 2, Federal Republic of Germany. (089) 849056.

Type Li62 switches are available in versions for direct soldering to printed-circuit boards. Variations include illuminated round or square pushbutton switches with momentary or push-on/push-off action, keyswitches with (or without) reset solenoids, cover safety switches and toggle switches. Also available are plugs and sockets with up to six poles. To install the pushbutton switches, the PC board should be mounted with a clearance of 30 mm from the equipment's front panel. This allows the operating buttons to protrude, and avoids the need for unsightly fixing screws. Also, the clearance provides room for other components, such as cradle relays, on the PC board. The Li62 components have a maximum of six contacts—either make, break or changeover. Contact rating is 30 V at 1 A. Operating voltage for release solenoids and buzzers is from 12 to 60 V dc or ac. Contact material is fine silver. Solder hooks are silver plated.

CIRCLE NO. 522

Toroidal transformers handle up to 330 VA

Intercontinental Electronica S.A., Mariano Cubi, 67, Barcelona, Spain. 200 49 41. Telex: 53930

Toroidal power transformers in the Omega series have ratings from 18 to 330 VA. The range will be expanded soon to include 475, 750 and 1000 VA sizes. Both standard and custom-designed types are available. Use of these transformers is becoming widespread for equipment requiring compactness, low weight, freedom from hum, minimum heat dissipation and a negligible external field. A static shield can be included between primary and secondary windings, if required.

CIRCLE NO. 523

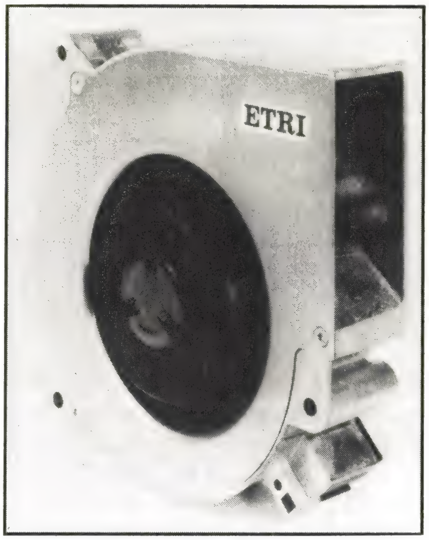
Transistors for hybrid ICs come in SOT-23 packages

N.V. Philips Gloeilampenfabrieken, Elcoma Div., P.O. Box 523, 5600 AM Eindhoven, The Netherlands. (040) 784616. Telex: 51573.

Four new transistors extend the range of SOT-23 transistors for hybrid ICs. They are the BCW81, a high-gain type, and three high-voltage types: BCV71, BCV72 and BCW89. The BCW81 has a max h_{FE} of 800, measured at a collector current of 2 mA. The device has voltage and current ratings of 45 V and 100 mA, respectively. Its f_T is 300 MHz. The BCV71, BCV72 and BCW89 all have rated voltages of 60 V and current ratings of 100 mA. The BCV71 and BCV72 are npn versions with maximum gains of 220 and 450, respectively. The BCW89 is a pnp type with a gain of 260.

CIRCLE NO. 524

Slim centrifugal fan runs very quietly



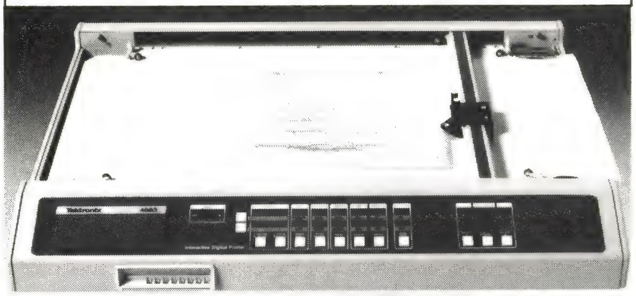
ETRI Fans, 3 Guildford Rd., Horsham, Sussex RH12 3 JT, England. Horsham (0403) 68797. Telex: 877235

Model 583-CBA-200, the latest in a range of slim-line centrifugal fans, uses sleeve bearings to achieve a low level of acoustic noise when running. Designed for heat transfer in electronic equipment, business machines and other applications where low noise is essential, the new fan has a thickness of only 38 mm. Yet, it can deliver 13.5 litres of air each seconds under normal 50-Hz operation in free-air conditions. At a pressure of 11.5 mm SWG, it delivers 6 litres/s. The fan uses an integral shaded-pole motor and has a nominal speed of 2550 rev/min at 50 Hz, and 2500 rev/min at 60 Hz. Maximum static pressure is 16 mm of H_2O at 60 Hz. The acoustic noise level is only 49.5 dBA The sleeve bearings require no lubrication. Overall measurements of the fan are 127.6 × 126.2 × 38 mm, and mounting is by three screws. The main body of the fan is a zinc-based alloy and the impellor is made of thermoplastic.

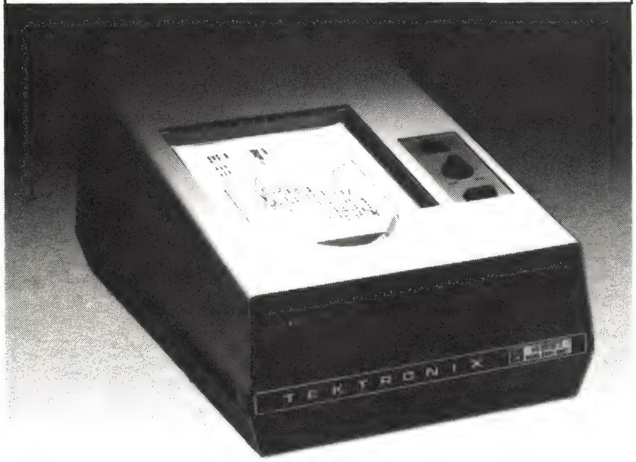
CIRCLE NO. 525

OEMs "talk to Tektronix" for plotters and copiers

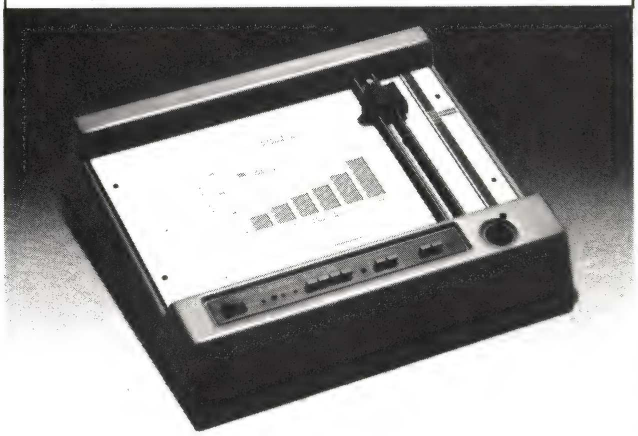
4663 plotter – economical A2-size alternative to large flat-bed plotters for reducing OEM system costs.



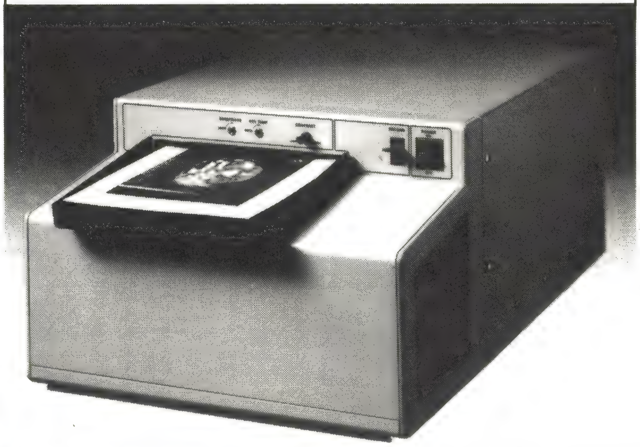
4632 – for OEMs needing quick copies from raster-scan displays.



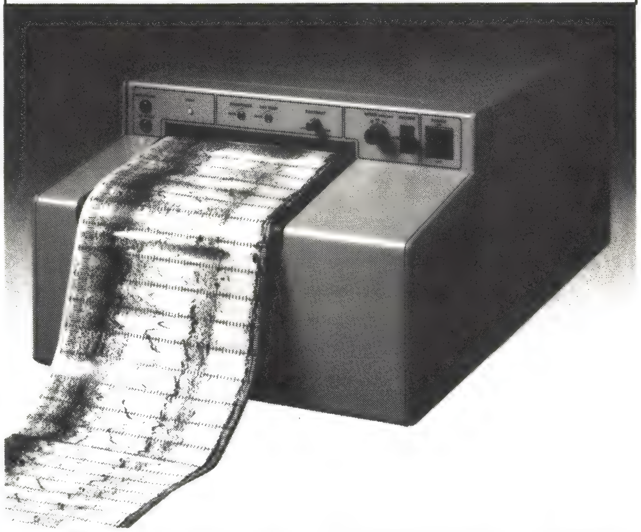
4662 – low-cost A3-size plotting for laboratory analysis, N/C tape verification & business management systems.



4634 – for high-quality grey-scale copies from video displays. Easily rackmounted too.



4633A – a continuous, real-time recorder for ultrasound, sonar or other line-scan applications.



Tektronix can solve your documenting problem. No matter what the OEM requirement for permanent copies – throughout system applications ranging from design and analysis to process control, medical imaging and management information – Tektronix has a wide and reliable range of plotters and copiers. Return the coupon for more details.

Tektronix International Inc.
European Marketing Centre, P.O.Box 827,
1180 AV Amstelveen, The Netherlands.

I am an OEM system builder. Please send me details of the following Tektronix plotters and copiers.

4663 ☐ 4632 ☐
4634 ☐ 4662 ☐
4633A ☐ General Graphics ☐

Name
Position
Company
Address

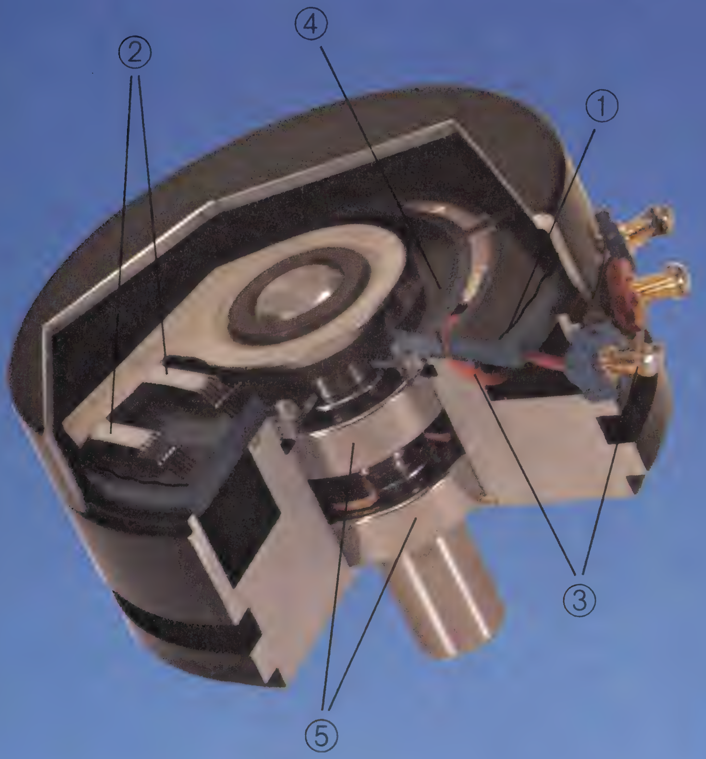
Telephone

Tektronix®
COMMITTED TO EXCELLENCE

CIRCLE NUMBER 118

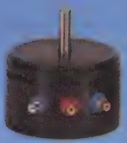
The new Quality Standard

With the Dinopot-HQ 5-System Novotechnik sets new standards for precision conductive-plastic potentiometers



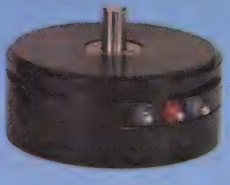
5 High-Quality characteristics:

1. Linearization of the assembled unit using its own wiper
2. Elastomer-damped wiper
3. Stress-relieved connections to the resistance track
4. Conductive-plastic collector track
5. Exactly aligned precision bearings



Servo size 11
1 1/16" (27 mm) dia.
Series P 2500

Servo size 13
1 7/16" (36,5 mm) dia.
Series P 4500



Servo size 20
2" (50,8 mm) dia.
Series P 6500

In addition to high reliability this technology offers you some performance data unattained thus far: Operating life of better than 100 x 10^6 revolutions at up to 1500 rpm - Maximum operating speed of 10,000 rpm - Linearities of up to ± 0.025%. All this at a surprisingly low price.

The conductive-plastic potentiometers Dinopot-HQ5 come in three sizes with resistance values of 1 kΩ, 2 kΩ and 5 kΩ.

For more information please contact

CIRCLE NUMBER 119

NOVOTECHNIK KG
Offterdinger GmbH & Co.
Horbstrasse 12
D-7302 Ostfildern 1
West Germany

Telephone: 0711/412921
Telex: 07-23681

novotechnik N

EUROPE

LOGICONTROL SPRL
Avenue Circulaire 130a
B-1180 Bruxelles/BELGIUM
Tel. 3747044

Société EQUIPIEL
218 bis, Bd. Péreire
F-75017 Paris/FRANCE
Tel. 574.14.97

VARIOHM COMPONENTS
The Barn, Wood Burcote
Towcester/Northants NN12 7JR/U.K.
Tel. 32751004 Telex 311754

TEKIND
Divisione della Sick Italiana
Corso Giambone 63
I-10134 Torino/ITALY
Tel. 635226 Telex 22298

Handelmaatschappij
ISOLECTRA B.V.
Dovenetelstraat 25
Rotterdam-3012/NETHERLANDS
Tel. 229000 Telex 22047

INTERMADOX GMBH
Josef-Moser-Gasse 1/15
A-1170 Wien/AUSTRIA
Tel. 464218 Telex 76780

Ingenjörsfirman
Gunnar Petterson
Box 117
S-12321 Farsta 1/SWEDEN
Tel. 930280 Telex 17944

INTERSTAR AG
Hochhaus I, Fridbach
CH-6300 ZUG/SWITZERLAND
Tel. 213255 Telex 78884

USA + CANADA

WATERS Manufacturing, Inc.
Longfellow Center
Wayland, Mass. 01778/USA
Tel. 617-358-2777

JAPAN

JAPAN ELECTRONICS CO., Ltd.
2-3-20 Nakamachi, Machida
Tokyo/JAPAN
Tel. 0427 (22) 2565

The case for CMOS crosspoints: Just these two RCA devices do the job of 48 relay switches.

If you're still using relays or high-current discrete switches in your telecommunications equipment, here are some good reasons to switch to RCA CMOS crosspoints.

With a single IC you can replace as many as 32 discrete switches, as well as the additional support circuitry normally needed for decoding and latching. This can improve reliability. Because the lower the parts count, the higher your reliability.

It also makes it possible for you to design much smaller products.

RCA crosspoint switches are available in three types. The CD22100, a device that combines a 4 to 16 decoder with a 4 × 4 array of crosspoints.

The CD22101 which combines a 4 to 16 decoder with a 4 × 4 × 2 array of crosspoints. And the CD22102 version which has a different input logic configuration.

All three devices feature low on-resistance, built-in control latches, 10 MHz switch bandwidths.

Plus the low power consumption and high noise immunity associated with all RCA CMOS devices.

RCA crosspoint switches are available immediately for volume orders.

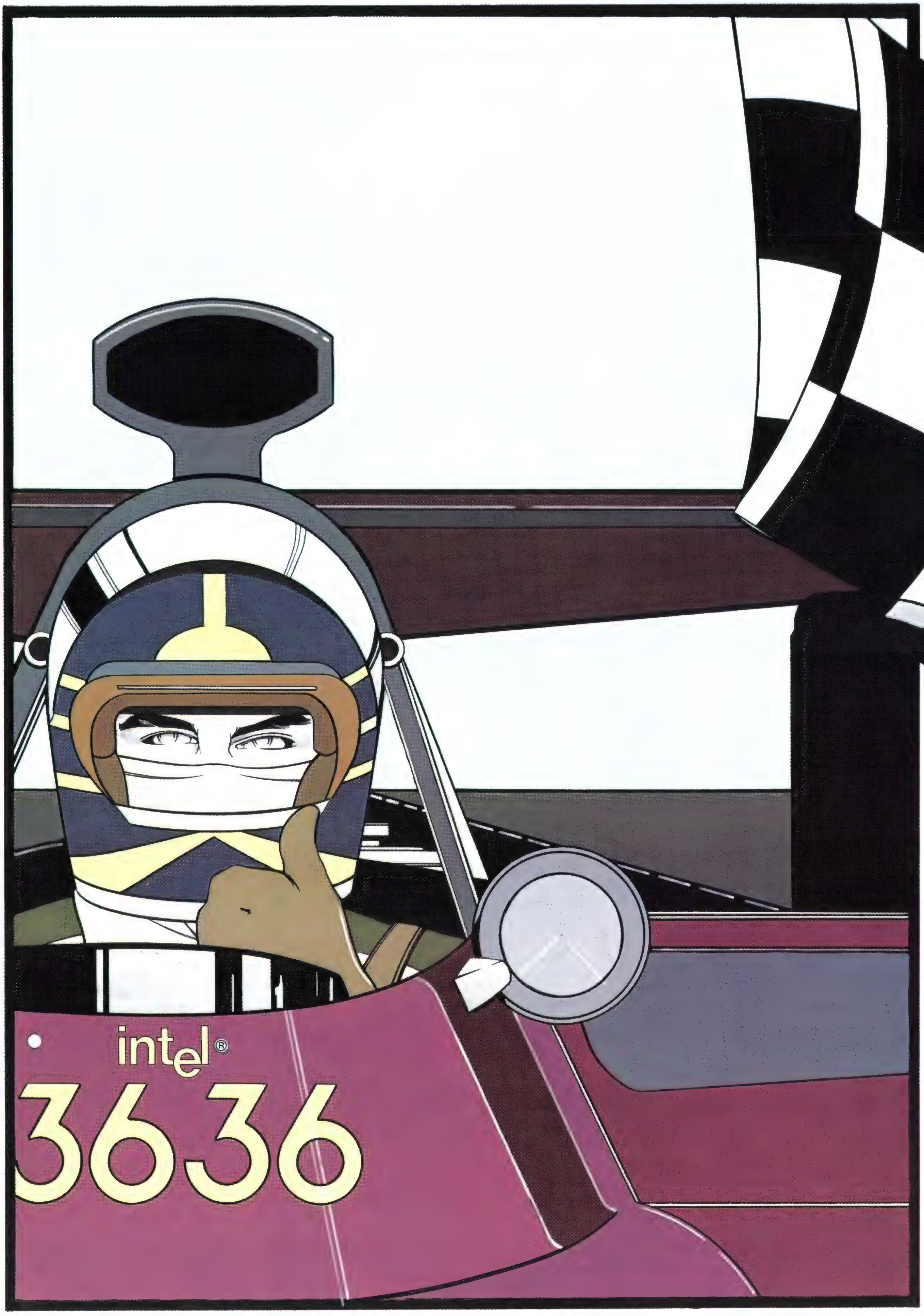
For further information, contact your local RCA Solid State Distributor.

Or RCA Solid State headquarters in Somerville, N.J. Brussels, Belgium. Tokyo, Japan.

The CD 22100: Equivalent to 16 relays.

The CD 22101: Equivalent to 32 relays.

CIRCLE NUMBER 109


intel®
3636

16K Speed Champ

Intel's new 3636 bipolar PROM breaks the 16K speed barrier with 65ns access. It's a victory for bit slice designs.

Streamlined performance is the whole point of today's advanced bit slice computers. High speed. High density. High reliability. Now Intel delivers the 16K 3636, manufactured with our new Stacked Fuse Bipolar* process to produce the highest performance microprogram memory yet.

Design for speed and comfort

Our 2Kx8-bit 3636 gives you four times the density of 4K bipolar PROMs with no speed penalty. The 3636's maximum access of 65ns makes it the ideal memory for fast, high density bit slice designs, as well as look-up table and other program store applications.

Using the 3636 instead of 4K PROMs lets you reduce component count and microprogram board requirements up to 75%. By designing program store on the CPU board, you can even save up to a full board slot for I/O or other functions.

For designs requiring extended temperature ranges, our 80ns military device, the M3636, is ideal.

No matter what your application, you're certain to reduce power requirements. Power consumption per bit for the 3636 is only one fourth that of most 4K bipolar PROMs and only half that of most 8Ks.

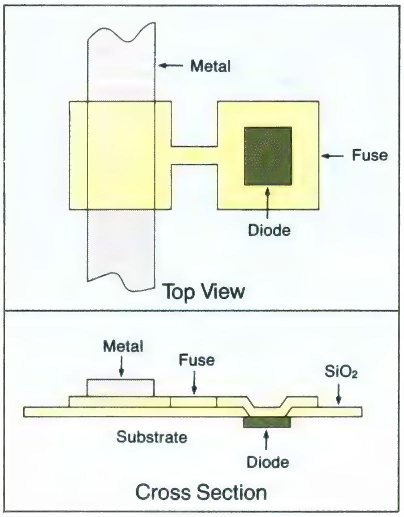
Whether you're replacing 4K or 8K bipolar devices, the 3636 makes it simple. It's packaged in the industry standard 24-pin DIP, so you won't have to redesign in order to upgrade. And you can program the 3636 in seconds using Intel's UPP103 or any standard PROM programmer.

Our formula: Stacked Fuse Bipolar

The most efficient way to improve speed characteristics of bipolar PROM's is to reduce die size. Very simply, smaller geometries reduce capacitance, thus speeding access time.

Intel achieved the 3636's high speed and dramatically smaller die size with a new "stacked" bipolar process. Stacked Fuse Bipolar combines Intel's expertise in Large Scale Integration with dual layer metalization and polysilicon fuses. (See diagram.) The result is the highest density and performance ever in a 16K bipolar PROM.

Stacked Polysilicon Fuse



Intel's new Stacked Fuse Bipolar process allows a 30% reduction in the 16K cell size. This dramatic density improvement yields faster access speeds than ever before possible. The illustration shows the "stacking" of our polysilicon fuse over the diode instead of placing them side by side as in older designs.

Intel's 3636 Bipolar PROMs			
	3636-1	3636	M3636
Maximum Access Time (ns)	65	80	80
Typical Power Per Bit (mW)	0.05	0.05	0.05

Intel's 3636 also means high reliability. We've already proven the producibility and dependability of Stacked Fuse technology with our 3625A 4K bipolar PROM. Hundreds of thousands of these components are already in operation, including military versions for hi-rel applications. In addition, millions of device-hours of tests with zero fuse failures confirm Stacked Fuse Bipolar's reliability. Further details on Intel's bipolar PROM reliability are found in our Summary Evaluation Report, RE1, available on request.

Get on the fast track today

Our high performance 3636 is available now. To order, or for complete data and reliability information, contact your local distributor or Intel sales office. Or write Intel Corporation, Literature Department, 3065 Bowers Avenue, Santa Clara, California 95051. Or call (408) 987-8080.

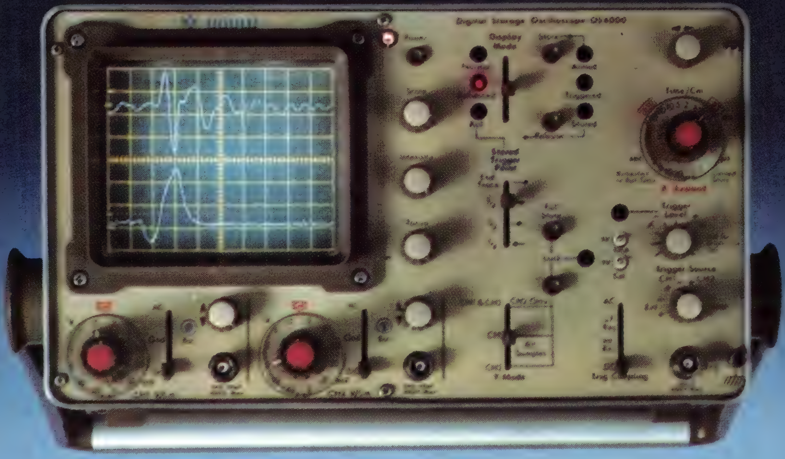
intel® delivers.

Europe: Intel International, Brussels, Belgium. Japan: Intel Japan, Tokyo. United States and Canadian distributors: Arrow Electronics, Alliance, Almac/Stroum, Component Specialties, Cramer, Hamilton/Avnet, Harvey, Industrial Components, Pioneer, Wyle/Elmar, Wyle/Liberty, L.A. Varah and Zentronics.

---

*Stacked Fuse Bipolar is a patented process of Intel Corporation.

CIRCLE NUMBER 110



Extend your storage capabilities beyond the conventional.

Now Gould offers a range of digital storage oscilloscopes that offer a world of advantages over conventional tube storage technology, beginning with being able to capture transient of "one-time" events and store them indefinitely for display or hardcopy printout. This makes them ideal for electronic, electromechanical, educational, and biophysical applications.

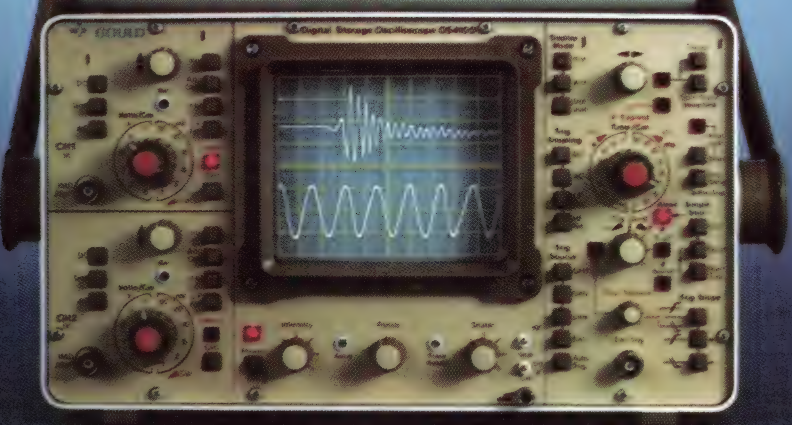
Both the OS4000 and the new OS4100 combine the capabilities of semi-conductor memory with a bright, stable, flicker-free display. This technique allows analysis of signal build-up and decay characteristics through pre- and post-trigger viewing. Expansion of the display after storage permits detailed study of specific areas of the trace.

The new model—OS4100—also offers you stored X-Y displays, channel sum o difference and a maximum of 100 V per cm sensitivity with noise suppression. A unique trigger window circuit assures capture o transients of unknown polarity.

Other outstanding features include automatic operation, display of stored and real time traces simultaneously and hard copy memory output in digital or analog form. And IEEE488 is available for compatible interfacing.

And, remember that Gould scopes are backed by a two-year warranty of parts and labor, exclusive of fuses, minor maintenance and calibration. For further information, contact Gould Inc., Instruments Division, 3631 Perkins Ave., Cleveland, Ohio 44114. Or Call (216) 361-3315, Ext. 395, for a demonstration.

GOULD
An Electrical/Electronics Company



CIRCLE NUMBER 111

Circular design improves trim factors of thick-film resistors

By laser trimming a circular design for thick-film resistors, manufacturers of hybrid circuits can obtain an unusual range of resistor values from any off-the-shelf ink. The circular design, from Electro Materials Corp. of America (Mamaroneck, NY), provides trim factors—the ratio of as-fired resistance to trimmed resistance—in excess of 1000.

In the new design, a round resistor pattern is placed on a ceramic substrate. The pattern interconnects at the center and at the circumference. A dielectric layer separates the center conductor from other parts of the resistor pattern. The appropriate resistor value is selected by laser trimming the thick-film pattern in a spiral outwards from the center.

Without trimming, the value of the circular resistor will be approximately ⅓ that of a square resistor made with the same material, or R (Ω per square)/π. Trimming in a spiral from the center increases the resistance value in multiples of 100. For example, a circular spot with a 0.480-in. diameter can be spiraled to yield a long resistance path with a width of 0.40 in. The resistance ratio between the spiraled piece and the untrimmed resistor is approximately 400:1. A spot of the same diameter, spiraled to a narrower 0.020-in.-wide resistance path, will provide a trim factor of 1600:1.

According to EMCA President George Lane, the merit of this design is that it allows the designer an extremely wide latitude in selecting the resistor value he needs from a single thick film in a single spot. The EMCA design increases resistance value many times with one trimming operation. Trimming increases resistance value by lengthening the path which the current must take through the resistor. Ordinary bar or "top hat" patterns limit the maximum length of the paths that can be created by trimming. Thus, the resistance value can increase only 50 to 200%.

The circular resistor design proves its worth when thick film must be prototyped on hybrid-circuit substrates. The designer can print a circular spot using any available resistor film, and can determine the precise value he requires by trimming.

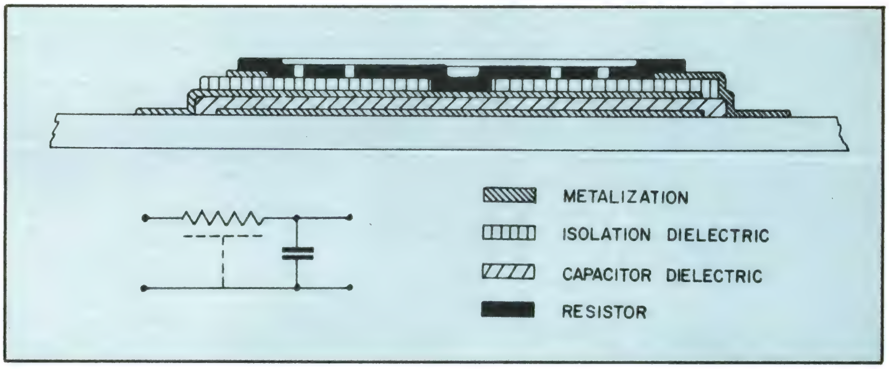
Tuning R-C circuits

Another application in which a high trim ratio is desirable is in the wide-band tuning of hybrid R-C networks. The capacitor can be a separate component, or the dielectric beneath the resistor can serve as the dielectric for a thick-film capacitor. The circular resistor then becomes a tunable distributed R-C network, occupying the same small area as a resistor on the hybrid-circuit substrate.

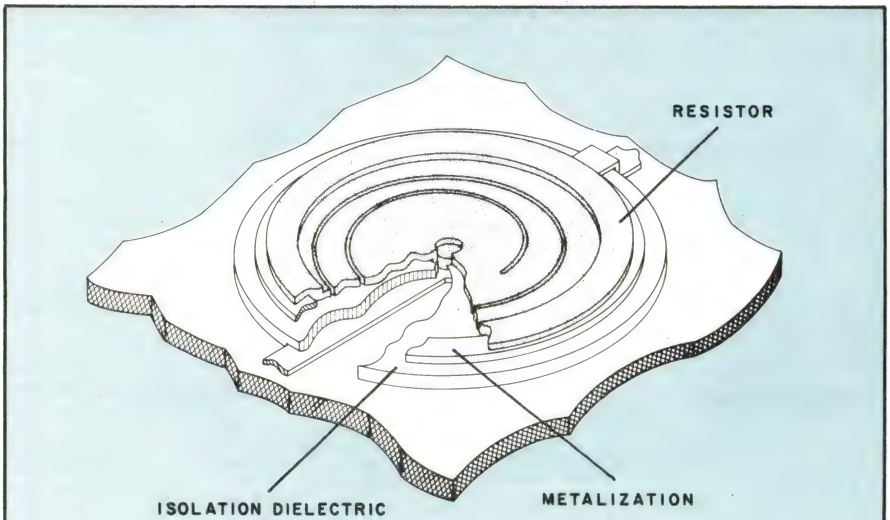
In other applications, the lower dielectric layer may be eliminated by using a plated-through hole in the hybrid-circuit substrate. Electrical contact with the center of the resistor is made from the underside of the substrate. Still other possibilities arise when the hybrid-circuit substrate is porcelainized steel.

The new process does require multiple printings, multiple firings and laser trimming equipment to obtain the spirals—all of which are costly. The savings, however, is in reducing the inventory of thick films, since many resistor values can be obtained by trimming from a single film.■■

Stephan Ohr
Components Editor



The dielectric layer beneath the circular resistor can be used as a capacitor, providing a tunable wide-band R-C network.

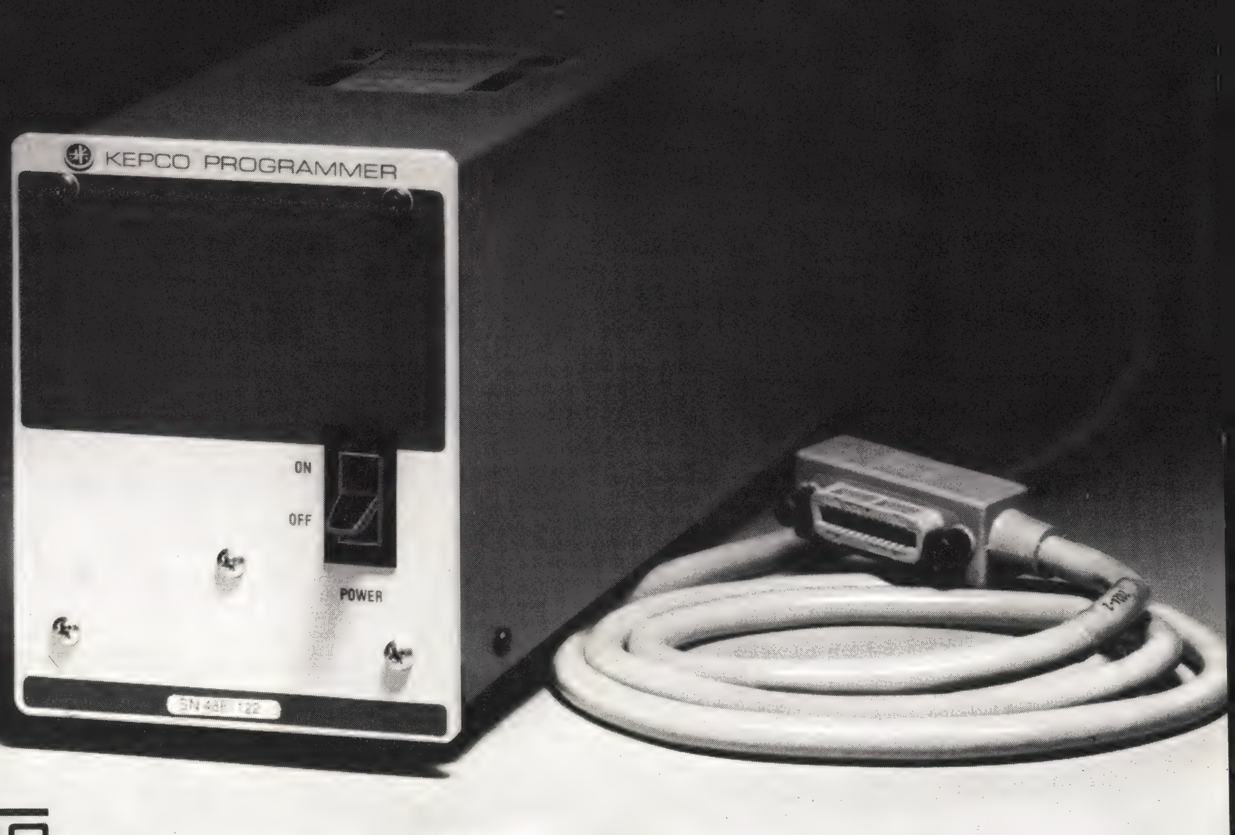


The circular resistor design is trimmed by spiraling the laser-beam outward from the center. Trim factors above 1000 are possible.

low cost
KEPCO IEEE-488
interface

series **SN 488** provides the connection between the bus and your analog instrumentation

- 12 bits, 2 ranges: 0.024% or 0.0024% resolution
- two optically isolated channels
- bipolar, plus and minus output
- compatible with Kepco programmable power supplies



KEPCO® For complete specifications, write Dept. CNF-05

KEPCO, INC. • 131-38 SANFORD AVENUE • FLUSHING, N.Y. 11352 U.S.A. • (212) 461-7000 • TWX #710-582-2631 • Cable: KEPCOPOWER NEWYORK

CIRCLE NUMBER 21

Congressman warns of inroads by imported ICs

Rep. Norman Mineta (D-CA) may have signaled a growing concern among legislators over the increase in semiconductor devices being imported from abroad, especially from Japan.

In a recent speech to his House colleagues, Mineta cited the contributions that the semi industry has made to the nation's productivity. He warned that the U.S. "open market" philosophy, coupled with cooperation between the Japanese government and its industry, could create serious difficulties for American companies manufacturing electronic components.

"Japanese firms are strongly tied to big business, the banks and the government, while U.S. companies are fiercely independent and competitive," said Mineta, whose home district includes San Jose, Cupertino, and Santa Clara—the heart of Silicon Valley. "Our market is open to all, but Japan's market is protected through restrictive trade practices. These and other factors threaten the health of our domestic semiconductor industry."

The Congressman urged House members to weigh carefully the findings of the House Ways and Means Subcommittee on Trade (which held hearings last year in San Jose, CA) and of the International Trade Commission (which recently investigated the semiconductor trade). The reports of both probes should soon be available to the public.

Executive order reorganizes trade bureaucracy

The Carter administration has also focused more of its attention on trade problems. An executive order, signed earlier this month by President Carter, reorganizes the nation's "trade bureaucracy."

The presidential order places most of the responsibility for trade policy in the office of special trade representative Reuben Askew. The Commerce Department will handle most of the day-to-day operations governing international trade. Under the plan, the Treasury Department will no longer handle investigations of product "dumping" and the State Department will no longer be responsible for the 162 commercial attachés stationed in 65 foreign countries. Both functions have been transferred to Commerce.

The reorganization should expedite and simplify solutions to trade problems, according to administration officials. Business leaders say Commerce may be more inclined than Treasury to protect domestic interests, a feeling that won immediate support for the plan in the business community.

IC copyright bill languishes in subcommittee

A bill to provide copyright protection for IC designs has mired in arguments over its worthiness, and may be dead. Introduced last spring by Rep. Don Edwards (D-CA), the bill is still in the House Judiciary subcommittee on copyrights; however, after heated debate the panel has ignored the legislation.

Under the bill, the designer of an IC would copyright the photomask design used to mass produce a chip—a more secure, faster and simpler protection than that now provided by patents. Edwards' measure received a very optimistic evaluation of its chances for passage when it was first introduced, but the support of IC makers weakened amid charges and countercharges of "pirating" designs.

Comsat gears up for TV system

The Communications Satellite Corp. (Comsat) has announced a joint venture with Sears, Roebuck and Co. to market small, receive-only, earth stations that would permit direct satellite-to-home television broadcasting.

Although arrangements with Sears, the nation's largest retailer, have not been completed, the pact could signal a shift in the plans for the system originally outlined by Comsat last August. At that time, the corporation intended to lease receiving antennas to customers for a fee that would include the cost of two to six channels of programming. Now, Comsat would sell the small dishes through Sears, which would also handle the servicing. The marketing know-how of Sears should boost Comsat's chances of succeeding with its first-of-a-kind system.

Robert Schwartz, a spokesman for Comsat, says the corporation is also hard at work on an application to the FCC for approval to operate the high-powered satellites that are essential to the project. The proposed satellites would transmit to inexpensive receivers, unlike the low-power transponders presently in orbit which require \$20,000 to \$30,000 ground antennas. In Japan, a high-power system now being tested uses Sony receivers that cost about \$300. The Comsat FCC application should be filed "early this year," Schwartz said.

The application may bring protests from the broadcasting and cable television industries, which consider the direct broadcasts a threat to the local-service tradition of today's television system.

EIA schedules defense research symposium

The Electronic Industries Association (EIA) has scheduled a symposium on the outlook for Defense Department spending on research, development, testing and evaluation, in fiscal 1981. The conference will be held April 15-17 in Washington, DC, according to EIA officials.

It will offer presentations by top executives from the Defense Department, Joint Chiefs of Staff, Defense Advanced Research Projects Agency and branches of the Armed Services. Congressional and White House experts will discuss defense spending and the expectations of the electronics industry.

Metric Board guides conversion planning

The U.S. Metric Board has unveiled a detailed set of guidelines to assist various industries in their conversion to the metric system. Although the switch to metric is voluntary, the USMB says the adoption of the system by the government and by many areas of private industry should spur more and more conversions.

The USMB rules will take industry groups step-by-step through the conversion, from planning to implementation. USMB will help these groups gather the outside comments needed to secure USMB approval for any conversion proposal, by publishing suggested plans and conducting public hearings.

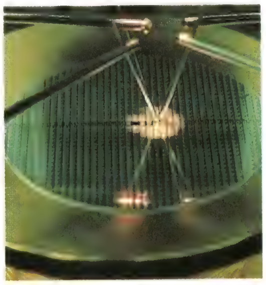
OSHA activities may be curtailed

The Occupational Safety and Health Administration (OSHA) may find many of its present tasks off limits, if a bill introduced by Sen. Richard Schweiker (R-PA) wins approval. The Schweiker bill, which has gained strong support in the Senate, would end routine OSHA safety inspections for up to 90% of the nation's 5-million workplaces.

The measure would prohibit routine safety checks for any company which has a good safety record, as verified by state compensation agencies. Companies reporting no injuries would be exempt automatically; those reporting a minimum number of injuries and no work-related deaths would have to qualify for exemption under OSHA regulations, to be issued under the bill.

The measure goes a step further than OSHA's recent exemption of companies employing ten persons or less, in industries with superior safety records. According to both the Schweiker bill and the OSHA rule change, OSHA will still investigate worker deaths and serious safety hazards and can conduct inspections after receiving employee complaints.

No compromise solutions.

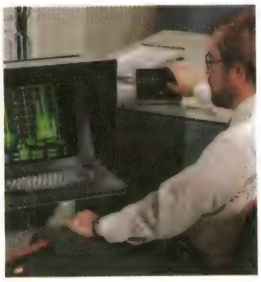


The Tektronix S-3280 is the first test system specifically designed to test ECL, LSI devices. Every S-3280 has high-speed drivers, giving you a pulse source for every channel. Precision fixturing allows you to connect the device to the tester with minimum signal distortion. And there are up to 64 channels of sampling for waveform analysis, ensuring high fidelity.

Flexibility.

Multiple pattern sources give you an effective, flexible means of implementing complex patterns. Choose the method of pattern generation that fits the device under test.

Compatibility.



Only one language to learn. All Tektronix S-3200 systems use TEKTEST, a test-oriented language very close to English. Your test engineers will quickly generate, edit, and debug device-testing programs.

Proven performance.

Semiconductor test systems are nothing new to Tektronix, we've been building them for years. In addition to the S-3280 ECL, LSI tester, there's the S-3270 for device characterization, and the S-3250 for production testing. Each has a 20 MHz clock rate. Our wide variety of options allows you to buy what you need now, and add to it anytime.

Training.

We'll support your test engineers with a comprehensive training program and thorough documentation.

Worldwide support.

We're a phone call away.

To find out which S-3200 system and its options best meet your needs, call your local Tektronix representative.

Tektronix®
COMMITTED TO EXCELLENCE

Another first from Tektronix. The high-speed solution for subnanosecond logic testing.

High-speed drivers.

Precision 50 ohm fixturing.

Waveform analysis.

We make moving ahead easy.

S-3280

Copyright © 1979, Tektronix, Inc. All rights reserved. 848

No matter what size LCD is in design . . . Our ZEBRA® LCD connectors are on the line.

- ZEBRA LCD connectors offer design flexibility to accommodate *any* size LCD.
- ZEBRA LCD connectors are available for shipment within one week for *any* size LCD.
- Over one billion reliable contacts made in the field.

TECKNIT®
129 DERMODY ST., CRANFORD, N.J. 07016 (201) 272-5500

The Conductive People

Minding the store

With this issue, Professional Perspectives makes its debut as a department (p. 129) that will appear in the first issue of every month. It's about changes in the engineering environment—what they are, where they are coming from, and who stands to benefit if they are (or are not) implemented. Everything from employee-employer "bread-and-butter" issues to the need for concerned engineers to speak out when conflicts exist between applied technology and public health or safety will be covered.

Look here, too, for news about proposed or pending legislation of particular interest to engineers (patent rights, pension reforms, etc.). Professional activities undertaken by the established engineering societies will also be reported and commented on. And legitimate, emerging engineering organizations of all types will be acknowledged and their progress monitored.

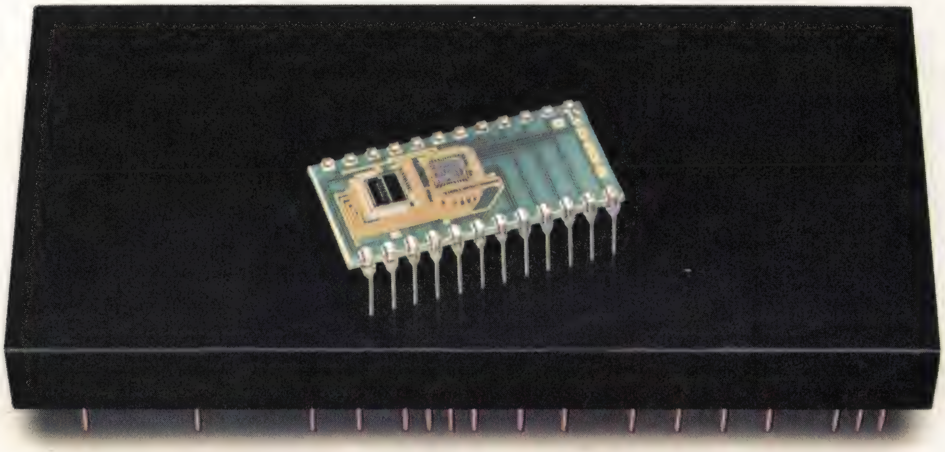
Why Professional Perspectives now? Frankly, it's an overdue recognition that the past decade has not been kind to engineers. Those believing that reward is based on accomplishment and merit alone have experienced disappointments and frustration: across-the-board salary levels that have not even kept up with inflation, nonexistent pensions, age discrimination, and industry talking "technological obsolescence" one day and "engineer shortage" the next. Yet, when mentioned at all, such problems are often tackled with brevity and poor documentation.

So get involved, readers. Your inputs and feedback can help make sure that significant, newsworthy developments affecting the engineering community are not overlooked. Professional Perspectives is for you.

Don Mennie

DON MENNIE
Associate Editor

Two Chips Off the Old Block.



A DAC with true 16-bit linearity... ...with just 2 chips...for $99.

So Long, Old Block.

Performance. Our new CMOS D/A converter can help you make design history. With ±0.0008% max. nonlinearity . . . four-quad multiplication . . . input storage registers in "byte-sized," 8-bit segments for microprocessor interface . . . 5 and 15V CMOS compatible as well as TTL . . . less than 1 ppm/°C linearity drift . . . 50mW power consumption . . . settling time less than 2μSec . . . ±10V reference input capability. And all with a single +15V supply.

Package. Our 24-pin package* is the new commercial standard for reliability. Based on a major innovation in monolithic processing, DAC9331-16 uses only two chips, featuring our own thin-film resistor network and proprietary monolithic switch set.* Result: unparalleled reliability, cost-effectiveness, and savings in size and weight.

*U.S. Patents Pending

Price. For fast turnaround, call or write.

Quantity	Price	Quantity	Price
1-9	$169.00	25-99	$119.00
10-24	$139.00	100-249	**$ 99.00**

For performance, experience and reliability, go with the leader.

Hybrid Systems
CORPORATION
Crosby Drive, Bedford, MA 01730
Phone (617) 275-1570
(TWX 710-326-7584 HYBRIDSYS BFRD)

In Germany: Hybrid Systems GmbH.
6100 Darmstadt, Luisenplatz 4, Germany
Tel. 6151-291595 (TELEX 419390 HYSY D)

In France: Hybrid Systems S.A.R.L.
14 Rue du Morvan SILIC 525
94633 Rungis CEDEX, France
Tel. 1-6878337 (TELEX 250969 HYSYS)

In the United Kingdom:
Hybrid (Component) Systems U.K. Ltd.
12A Park Street, Camberley, Surrey
Tel. (0276) 28128 (TELEX 858720 HYBRID G)

CIRCLE NUMBER 20

ATE packs new weapons as LSI invades components and boards

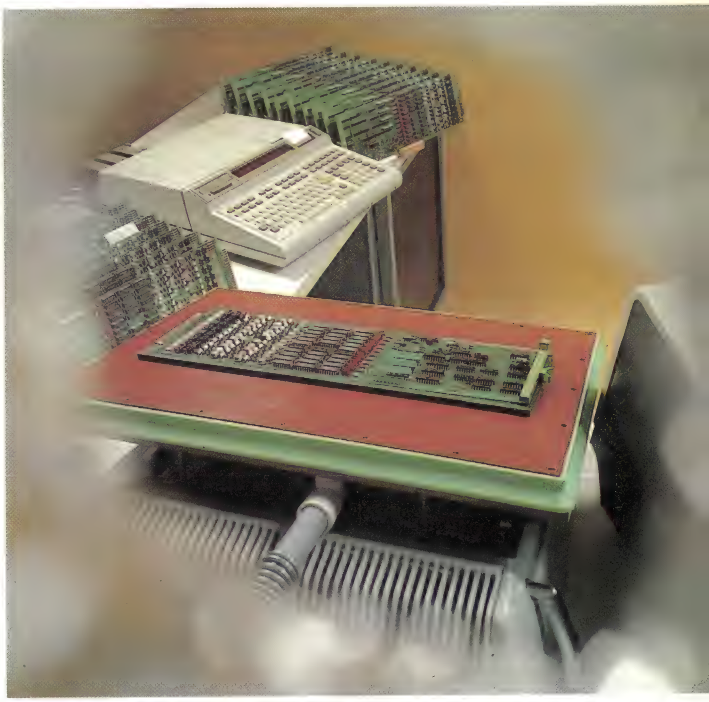
For automatic test equipment, it's getting to be a very demanding—and changing—world. At component and board level alike, ATE is being pushed to do more testing faster by the spreading LSI invasion. The onslaught ranges from new analog components to analog/digital boards. Meanwhile, as boards become crowded with new circuitry, finding faults is fast becoming a challenging virtue for a variety of board testers.

Faced with a growing list of required capabilities, ATE manufacturers are taking the offensive:

- In component testing, the push is on for more clock speed and performance as well as for software and hardware to test the new crop of analog LSI components, notably the codec.
- In general-purpose board testing, faster clock rates are also a prime target, along with new ways to test not only analog boards but also hybrid boards —those with mixed analog and digital circuitry. Beyond go/no-go board testing, innovations abound to isolate faults—automatic fault isolation, which pinpoints a faulty node, and sophisticated probes that ferret out the faulty component automatically.
- In memory-board testing, more functional capability is being added to check the new SSI, MSI and LSI accessory circuits taking over the board real estate left over by increasingly dense memory components.
- In in-circuit board testing, techniques are being developed to permit LSI as well as SSI and MSI logic to be checked in-circuit as easily as a resistor.

"Across the board," speed is livening things up. ICs are getting faster, so ATE is struggling to keep pace —struggling because of speed limitations, in some cases imposed by the complex sequence of events taking place: generating the test pattern for the device being tested, comparing the expected response with the actual response from the device, and then analyzing detected faults.

New speed weapons are called for, and Fairchild's (San Jose, CA) new Sentry Series 20 answers the call with 100-k ECL logic, which takes patterns pipelined from the tester's main CPU memory, and feeds the patterns into 4-k local memory at the test head. From there, the patterns shift serially out to the device under test at a 20-MHz rate—a speed not possible with this method before the availability of the company's new ECL family.



Some large-board test systems like the Hewlett-Packard 3060A offer both in-circuit component testing and functional board testing.

Before 100-k ECL, machines like the Tektronix (Beaverton, OR) 3280 multiplexed a number of shift registers together, using discrete logic, to produce a 20-MHz bit stream. Thus, four 5-MHz shift registers, when multiplexed, produced a 20-MHz bit stream. The 3280 also features 4 k of local memory, 4 k of optional memory and 1-ns resolution of clock pulses.

Generating the pattern is only one aspect of the speed problem. It takes time to determine whether the device has passed or failed and, if it has failed, to determine the cause. In the pass/fail portion of the test sequence, the drag on speed is the comparator —usually a threshold detector that compares the known-good bit stream with the actual bit stream

---

Jonah McLeod
Instruments Editor

from the device under test. Such a detector is chockfull of inherently slow analog circuits and feedback loops.

Put it all together

One solution is described by Hiromi Maruyama and Shigeru Sugamori of Takeda Riken Industry Co., Ltd. (Japan) and Tsuneta Sudo and Yoshichika Ichimaya of Nippon Telephone & Telegraph (Japan). They claim to have developed a hybrid comparator IC with a blazing input transition time of 700 ps, which supports a system that reportedly runs at a staggering 100 MHz, faster than any other tester.

At this point, however, 20 MHz is about the limit for general-purpose testers, which need substantial local memory to handle a wide variety of devices. Memory testers, however, don't have to be as versatile and can work a bit faster. The Fairchild Xincom (Chatsworth, CA) 5582, for example, calls upon a pattern generator and a fast ECL memory to squeeze 25 MHz into its memory-pattern stimulus. Similarly, the Macrodata (Woodland Hills, CA) M1 achieves a 25-MHz clock speed.

While speed is a big factor in component testing, it is not the only big factor—overall performance weighs just as heavily in the buyer's mind. State-of-the-art performance is exemplified by the J387A Memory Test System from Teradyne (Woodland Hills), the Xincom 5582 and the Macrodata M1. All three offer outstanding accuracy—less than 1.5 ns for access time, cycle time and timing pulses. Previous-generation devices had 3-ns accuracy. Driver skew is another important spec—the time differential between data, address and timing pulses applied to the memory being tested. On all three systems, the skew is at most 500 ps.

Up to now, data-driver skew was not critical, since only one driver was needed for the prevailing 1-bit-wide RAM devices. But with 4 and 8-bit-wide RAMs beginning to dominate, this skew is increasing in importance.

To ensure that this clock-edge precision remains consistent, memory-test systems usually incorporate some form of calibration capability. The 500-ps accuracy in the Teradyne unit is assured by a test fixture inserted into the prober/handler of the system test socket. With the fixture installed, the test-system computer automatically readjusts the 12 edges of the six clock pulses from the timing drivers. On the Macrodata M1, clock, data and address lines are automatically calibrated without requiring a test fixture.

Across from the clock drivers reside the comparator circuits, which can be a trouble spot because of the different ways they are used. One approach is a window-comparator; another, an edge comparator.

With a window comparator, a window is established by the start and stop edges of the comparator strobe, and becomes the period during which the output from the memory is examined. An edge comparator, on the other hand, looks only at the leading edge of the pulse from the memory. The problem is, if a part is tested on one type of machine and then on the other, the results may be slightly inconsistent.

High speed and performance usually command a lofty price, say from $250,000 to $500,000. However, many ATE suppliers are combining a lower price tag

Older-vintage component-test systems such as the Tektronix S3200 series provide state-of-the-art 20-MHz testing capability by multiplexing the output of 5-MHz shift registers to produce a composite 20-MHz bit stream.

A one-of-a-kind automated test bench, Teradyne's L621 is intended primarily to test analog boards containing a minimum of on-board digital logic.

with some pretty impressive specifications.

At the low end are IC test systems like the recently announced GenRad (Concord, MA) 1732 digital IC test system. For $32,000, the system offers a 2-MHz clock rate and enough capability to test LSI components, including memory. As many as 48 driver/sensor pins are available.

In addition, there is enough software to write test programs for the devices to be tested as well as automatic self-calibration to ensure that voltage, current, offsets and gain variations used in parametric testing are accurate.

If LSI testing isn't needed and a 1-MHz clock rate is adequate, there is the Siemens (Cherry Hill, NJ) Model 725 IC tester, which for $25,000 to $40,000 can support two test heads for faster testing throughput.

For about $45,000, the M7 system from Micro Control Company (Minneapolis, MN) offers a 10-MHz clock rate as well as most of the capability found on the lower-priced systems. The speedier clock results from using a 10-MHz pattern processor instead of the slower processors found on the other units.

Around $60,000 to $120,000 buys a Q11 system from Megatest (Santa Clara, CA) or the MX-17 test system from Adar (Burlington, MA). In this price range, accuracy at the pin electronics is in the neighborhood of ±2 ns (computer-aided calibration keeps accuracy high) and test speed is 10 MHz. The MX-17 also carries 40 bidirectional channels and full ac and dc parametric testing capability.

While increasingly dense digital LSI keeps pushing the test system to do more, a whole new set of testing problems has arisen with the addition of analog capability to LSI components—especially codecs.

In general, codec testing involves stimulating the decoder portion of the codec with a digital signal having a known analog equivalent, and then checking the output waveform for the various test values, response, distortion, and so on. For the encoder portion, a similar evaluation occurs on the digital output in response to an analog stimulus.

The problem is, the digital input for the decoder portion of the device is not a linear representation of the analog output. Likewise, the analog input to the device's encoder portion is converted into a digital logarithmic representation of a point or quantizing level on the sine wave being encoded.

Codecs check out

Two testing methods are currently being promulgated to test codecs, one a purely digital solution advocated by Fairchild, the other a combined digital and analog solution advocated by Teradyne (Boston, MA). In the digital solution, analog stimulation is provided by a digital pattern generator that supplies a bit stream to the on-board digital-to-analog converter. The converter, in turn, produces an analog input signal. In the combined solution, a programmable audio source generates the stimulus.

For the decoder portion of the codec, both methods generate the needed digital signal. However, in the combined technique, a programmable high-speed audio voltmeter determines the actual analog level;

the digital technique uses a high-speed sampler tied to a math package that performs a Fourier analysis. (For a discussion of the digital method, see p. 59).

Teradyne, citing its A300-series analog test system, claims a measurement time of 3 seconds maximum to test a codec completely, including all dc parametrics and all ac measurements associated with the decoder portion of the codec. By comparison, the time required for the same measurement with the digital technique is determined by the time required for the computer to do a complete Fourier analysis. At present, Fairchild claims 10 s for a complete codec test.

Teradyne and Fairchild spearhead the two opposing approaches to the codec-testing problem, Tektronix may soon join one of the two camps. The company is reportedly working on a general-purpose IC test system coupled with precision analog features designed for easy calibration by software.

Board-testing blitz

Meanwhile, the chief concerns at the component testing level—speed, performance, digital, analog—are the chief concerns at the board-testing level. While speed and performance are going up, general-purpose analog-testing capability is making a resurgence in both stand-alone and digital board-testing systems.

At the same time, the distinctions marking the various kinds of board testers are blurring. Special-purpose memory-board units are taking on some general-purpose functional test capability, and in-circuit testers are adding functional muscle to help address the problem of testing the SSI, MSI and LSI components that make up most PC boards today.

Like component testers, the board testers stimulate the card under test, determine if a fault exists, and then isolate the fault to uncover the failing party. But because the circuit being tested is repairable as well as expensive, finding the faults gets much more attention at this level. As a result, technological improvements here focus not only on stimulus and response-monitor hardware and software that models the board under test for fault isolation, but also on software and hardware options for fault location.

All these developments point to a sharp division of opinion among board-test ATE vendors as to which ways their equipment should be developing. Bob Anderson, vice president of Omnicomp (Phoenix, AZ), believes that higher testing speed is needed. Citing the increasing use of LSI right on the board, he notes that not only must normal testing functions be carried out on-board, but dynamic ICs must be "kept alive" with refreshing and clocking signals. What's more, the LSI must be run at or near clock rates or actual operating speed to verify correct operation.

According to Anderson, ATE makers with systems fast enough to test at component speed believe that testing must be performed at operating speed because the operation and failure modes of LSI devices are relatively unfamiliar and because simulators cannot

Like other board testers, Computer Automation's 4900 can test digital boards containing some analog circuitry. Its main advance, however, is the 4814 software simulator, recently added for modeling boards to be tested.

A relative newcomer to the ATE market is the bubble-memory tester by Megatest. Watkins-Johnson is another supplier in this small market segment.

model all faults that can occur in an LSI device.

On the opposing side are ATE vendors that do not offer clock-rate testing. The real issue, to them, is not testing at speed, but the percentage of faults detected. The faults in question include dead LSI devices, unwanted interactions between ICs, and previously undetected manufacturing faults.

Currently, for general-purpose board-test systems like Fairchild's (Latham, NY) Series 70 (ELECTRONIC DESIGN, Jan. 4, 1980, p. 172), Teradyne's L135, and Fluke's (Mountain View, CA) 3040, 10 MHz represents the upper end of clock speed. (The clock speed cited for the Fluke system ranges from 1 Hz to 9.99 MHz. The Teradyne system shows 100 Hz to 5 MHz, while the Fairchild system reportedly clocks in at 5 MHz, with the ability to generate clocks above and below.) Will the high end ever rise to 20 MHz? No, says Anderson, reasoning that dynamic board testers with that sort of capability would be prohibitive in cost for most manufacturing environments.

Whatever the outcome in speed, the wraps are definitely off on functional analog testing capability —not only are hybrid board testers emerging but dedicated analog units as well.

Why the renewed emphasis on analog capability? A variety of reasons. First, LSI—and now VLSI—puts so many functions on-chip that board space is being freed. Analog functions that would have been relegated to a separate board are filling in the empty board real estate.

Second, the explosion in tele and data-comm ICs has led to a mixed bag of analog and digital circuits working together—the codec, for instance.

To test this array of hybrid boards, a new generation of ATE has sprung up, characterized by the ability to perform not only functional parametric tests but integrated analog and digital testing as well. This group includes the Fairchild Series 70, the GenRad 1796 and 1799 series of testers, the Fluke 3040A, the Hewlett-Packard (Loveland, CO) 3060A and the Teradyne L135, and the Computer Automation (Irvine, CA) 4900.

Most hybrid systems also offer guided-probe diagnostics down to the node level. Thus, the system fault-isolation software can be used to troubleshoot in either the analog circuitry or digital logic of a board. This is a significant feat since most fault simulators consist of digital-test software programs that must be modified to accommodate analog faults.

Another feature becoming available on hybrid test systems is the ability to perform real-time dynamic tests on on-board memory. The Teradyne L135 stores patterns and allows algorithmic testing of ROM and RAM even if the memory is buried in the circuit, as is the case with scratchpad memory on some intelligent controller cards.

At the opposite end of the spectrum from digital testers with some analog capability is one analog system with some digital capability: the L621 from Teradyne. Basically, it's an automated test bench with

By providing functional ability to test the digital logic found on IBM-compatible memory boards, the Testmaster 6000 can reduce board-test time by a factor of five.

Board-test systems in the Fluke 3040A class are all offering the ability to test the current generation of hybrid boards: digital boards containing some analog circuitry.

a collection of test equipment that permits testing of boards packing mostly analog components. Its digital capability accommodates DAC and ADC-type testing.

Another area of activity in general-purpose board testers is data-compression techniques, which are implemented mostly in small, $25,000, bench-type testers like the GenRad 2225 and Omnicomp PSP testers, as well as the Three Phoenix Co.'s (Phoenix, AZ) 3PX550 tester. However, the technique also shows up in larger systems like the HP 3060A and the Fairchild Series 70.

Its popularity is well-founded. In place of test patterns that would require large amounts of memory, stimulus data are compressed, thus saving storage space. Then, during fault analysis, the system looks not for a long pattern test but for a signature that indicates proper operation of a node. (For more information on signature analysis, see pp. 65 and 75).

For small systems, data compression saves memory. For large systems, data compression saves programming time, which means test programs can be completed more quickly for any given circuit. There are drawbacks, however, notably during fault isolation within a feedback loop. While the stimulus is being compressed, all reference to time is lost. Data within a feedback loop are constantly being fed back, so unless the time length for any one signature is known for any given node within the loop, it is impossible to determine if the node is operating properly.

In the past, the only way around this was to open the loop. That's all changed with GenRad's 2225 tester and Omnicomp's PSP, both of which isolate faults without having to open the loop. Somehow, the start time of each signature is retained. How is a mystery —a patent is being sought for the method, so details are hard to come by.

Some bench-type testers do not employ signature analysis, but opt for other techniques to save space in memory. The Bendix (Teterboro, NJ) 13A9070 digital module tester, for example, which can test chips as well as boards, employs the complete stimulus pattern.

Beyond the node

At any rate, once a fault has been isolated, most testers use some form of guided-probe operation to get to the faulty node. The computer within the test system tells the operator to move the probe from place to place on the faulty logic card. Then, after playing a game of "whodunit" with the board-logic diagram stored in the test-system memory, the computer stops and indicates the failing node.

Up to now, an operator, usually a test technician, would then begin troubleshooting beyond the node to find the actual failing device. However, options offered by Teradyne, GenRad, Fairchild and Computer Automation make most of this unnecessary.

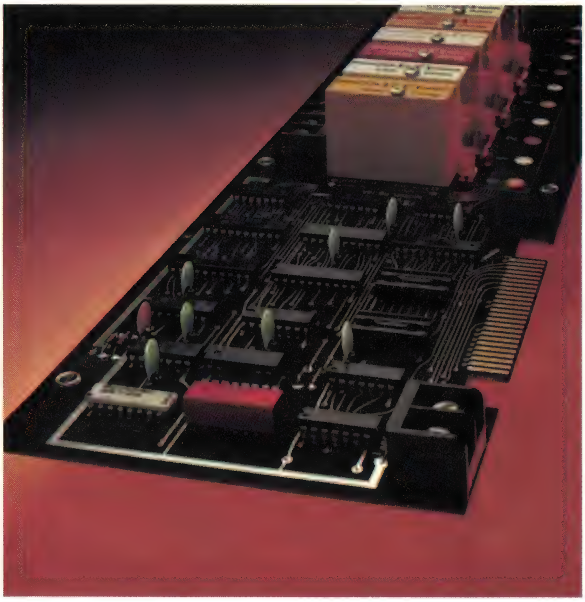
Teradyne's "Electronic Knife" isolates the problem beyond the node by injecting currents and carefully analyzing return current to distinguish between a correctly enabled gate and a faulty one. GenRad's "Bug Hound" and Fairchild's "Flow Tracer" inject current the same way, but rather than look for return current via a contact probe, they have a sensitive probe that detects flux generated by current flow in a circuit run on the board. To isolate a faulty short, the flux-detector probe follows the circuit run path until it

Memory-board test systems such as the Adar 12/30 are grappling with the increasingly larger amounts of discrete digital logic appearing on memory boards by offering some digital functional test capabilities.

Speed and performance are kept on a budget thanks to such digital IC test systems as the GenRad 1732. For $32,000, the buyer can test small-to-large-scale ICs.

ADDRESSABLE I/O SYSTEMS FROM OPTO 22

(PB 16S1)



(PB 16P1)

Huntington Beach, California . . . Opto 22, originators of the industry standard I/O system, announces the second generation in I/O Systems in both serial and parallel configurations.

SERIAL ADDRESSABLE RACK (PB 16S1)
Communication with multiple input/output stations.
32 station address capability per serial loop.
Up to 16 power I/O modules per station.
Switch selectable baud rate.
Opto 22 provided firmware includes message protocol, event counter, self test, watch dog timer and more.
Plug in modules provide choice of:
1. 20 Ma Current Loop.
2. RS 422 Balanced Differential Drivers and Receivers.
3. Optically Coupled Drivers and Receivers.
4. RS 232

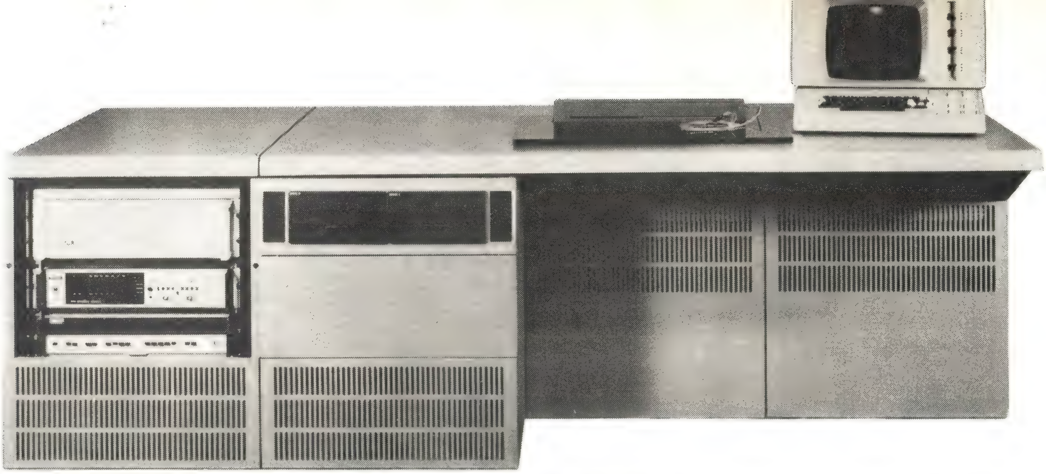
PARALLEL ADDRESSABLE RACK (PB 16P1)
Bidirectional Communication with input or output modules.
64 station address capability.
Up to 16 Power Input/Output modules per station.
50 Conductor Daisy-Chain cable connects all racks to host controller.
On-board station address select switch.

15272 Relay Circle, Huntington Beach, CA 92649
(714) 892-3313

opto 22

Another Opto 22 product available for immediate shipment.

CIRCLE NUMBER 23



A 5-MHz test rate and fault-isolation capability that goes well beyond node-fault location are two of the key features found on most current board-test systems and typified by the recently announced Fairchild Series 70.

he Troubleshooter 800 from Plantronics/Zehntel uses ignature analysis for testing individual devices on an LSI oard.

detects a diversion of current. To counteract shorts in power rails where injected current from the "Hound" would be diffused within the rails, a microammeter is substituted for the flux detector. Beyond-the-node fault isolation in the Computer Automation tester is called "advanced fault isolation." It combines features of both methods already described.

On the special-purpose side, memory-board testers resemble general-purpose units by testing board functions, not board components. Technology issues being addressed are also similar. For example, suppliers like Adar, which offers the DR 12/30, and Macrodata with its newly enhanced MD207-11, are being encouraged to incorporate more functional test capability on the system to handle the increasing influx of LSI components. With memory getting denser, less board space is required to contain large amounts of memory. As a result, manufacturers are beginning to fill this space with logic.

A more specific example involves a memory-board supplier, Testmaster (Costa Mesa, CA), which also manufactures testers capable of testing memory boards bound for IBM-compatible systems. Here, the supplier must develop tests that can effectively test the interleave controller found on these memory boards. The interleave controller permits the memory system to operate at higher memory speeds. The tester involved, the Testmaster 6000, also derives an advantage from testing the interleave controller—cutting test time per memory board by a factor of five.

The in-circuit segment features some familiar suppliers, among them Fairchild, GenRad, Hewlett-Packard and Computer Automation. One company, however, that supplies exclusively in this segment is Plantronics/Zehntel, Inc. (Concord, CA). Its latest product, the TS-800, uses a low-impedance driver to isolate devices within a larger circuit for testing. What's more, it effectively isolates and then stimulates an LSI component within a circuit for testing. It then uses signature analysis to determine proper operation of the component. ■■

...in one cost-effective system.

AMPLIMITE Connectors come in a complete line to meet virtually any need for high density pin and socket connections. Military versions with screw machine contacts meet MIL C-24308. Commercial versions include all-plastic types designed for both board and jacketed cable applications plus ribbon cable types for providing economical and reliable mass termination capability.

With all of these connections AMP furnishes a wide selection of contacts in continuous strip for machine termination or in loose form for hand tool applications. The AMP Stripper/Crimper Machine strips the wire and attaches a contact during each machine cycle. It crimps at speeds of up to 1500 terminations an hour.

For the complete story on AMPLIMITE Connectors, Tooling and the AMP Technical Support that goes with them, call the AMPLIMITE Information Desk at (717) 780-8400. Or write AMP Incorporated, Harrisburg, PA 17105.

AMP and AMPLIMITE are trademarks of AMP Incorporated

AMP

Check Reader Service No. 89

Now AMP's extensive line of pin and socket connectors includes everything you need to interface with modems in accordance with RS 449. That means 9- and 37-position sizes to go with the 25-position, and squeeze-to-release hardware that also can be screwed together.

You bet we do. AMPLIN

AMP engineers also designed 90° posted header and interface style connectors with their exclusive Quiet-Line absorptive filters. With the highest insertion loss specifications in the industry, these filters wipe out interference by dissipating it as a small amount of heat. No more ground current loops. And the interface connector lets you filter existing designs without redesign or rewiring.

For wire-to-board applications, there is an exclusive all-plastic header with compliant pins for press fit without solder. And shielded back shells are available for cable connectors.

AMPLIMITE Connectors are available, of course, with a wide variety of contacts and reliable stripper crimper machines.

That's it. Everything you need to meet RS 449. And more. For the rest of the story, see the opposite page and the page overleaf.

AMP and AMPLIMITE are trademarks of AMP Incorporated.

AMP has a better way.

ITE Connectors.

Some facts worth knowing about AMPLIMITE Connectors

Electrical Characteristics

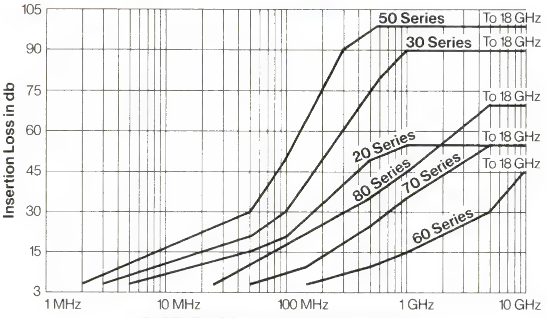
Contact Current Rating (with No. 20 AWG/0.5—0.6 mm²/wire): 7.5A
Contact Resistance: 7.3 Milliohms (max.)
Dielectric Withstanding Voltage: 1000 V (min.)
Insulation Resistance: 5000 Megohms

Mechanical Characteristics

Contact Engagement Force: 12.0 Oz./3.4 N/(max.)
Contact Separation Force: 0.75 Oz./0.2 N/(min.)
Contact Retention: 10 lb./44.4 N/(min.)
Connector Mating Force (per contact): 8 Oz./2.224 N/(max.)

Filtered Connector Data (20 Series)

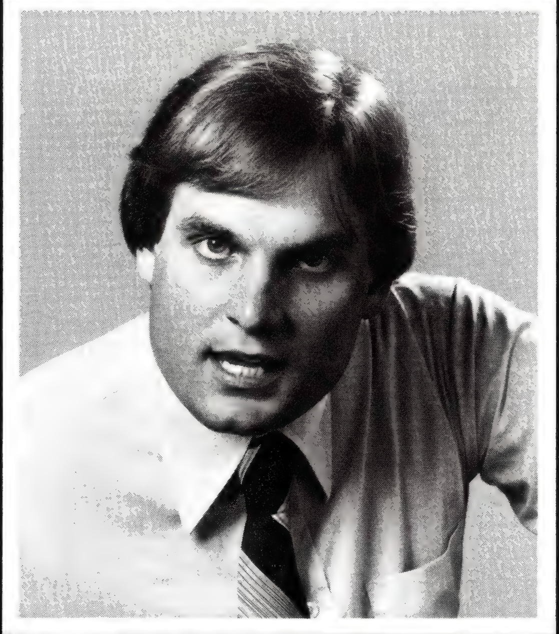
Cutoff Frequency: 5 MHz
Insertion Loss: 55 db from 1 GHz to 18 GHz (per MIL-STD-220)
Insulation Resistance: 500 Megohms at +25°C (min.)
Dielectric Withstanding Voltage: 250 VDC for 5 sec.
Higher performance filters available:

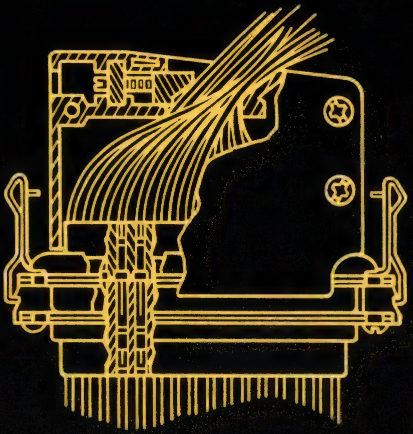


FILTERED CONNECTOR PERFORMANCE

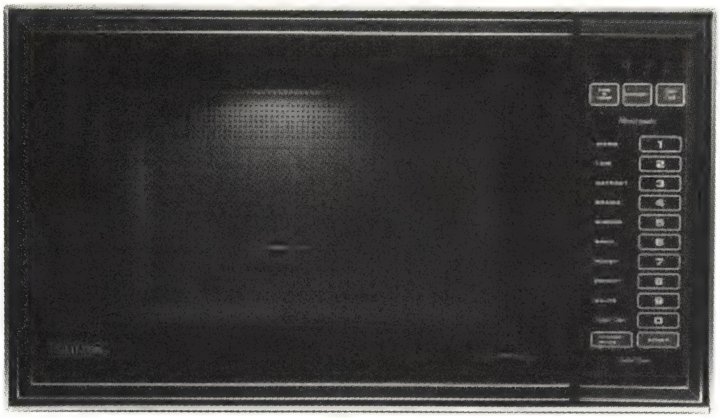
Where to telephone: Call AMPLIMITE Information Desk (717) 780-8400.
Where to write: AMP Incorporated, Harrisburg, PA 17105.
Product Information: Check Reader Service No. **89**

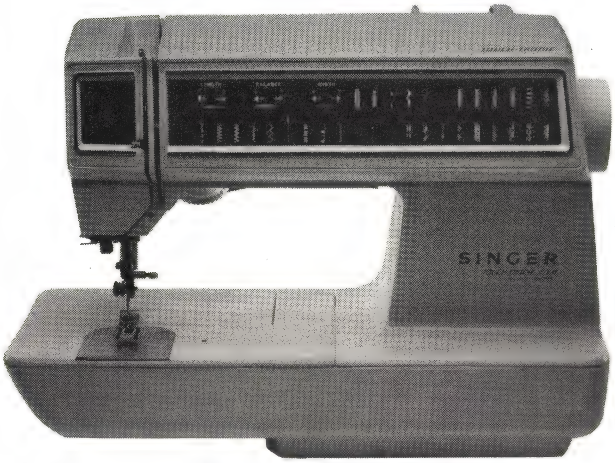
"Today, it's RS 232
on subminiature D-type
connectors, but RS 449
is just around the corner.
Got anything to meet it?"





The PPG Touch.





Prototype model

It's PPG *Nesa*® and *Nesatron*® electronic glass. Incredibly versatile products with applications ranging from touch control panels to visual display devices.

A PPG *Nesa* glass touch control panel can replace virtually any electro-mechanical device. It's activated by the touch of a finger. And because there are no moving parts and nothing to break off, it simply does not wear out.

Then there's PPG *Nesatron.* Use it in a visual display device. It'll enhance any design with its sleek combination of function, durability and elegance.

Consider the infinite present and future applications of both PPG electronic glasses: telephones, vending machines, microwave ovens, sewing machines, calculators, watches and instrumentation panels. The list goes on and on.

Learn more. Return the coupon today and start applying the PPG touch to your designs.

PPG: a Concern for the Future

PPG INDUSTRIES

Industrial Glass Products
PPG Industries, Inc.
One Gateway Center
Pittsburgh, Pa. 15222

ED-120

Please send your technical and sales brochures about PPG *Nesa*® and *Nesatron*® electronic glass.

Name____________________

Company____________________

Title____________________

Street____________________

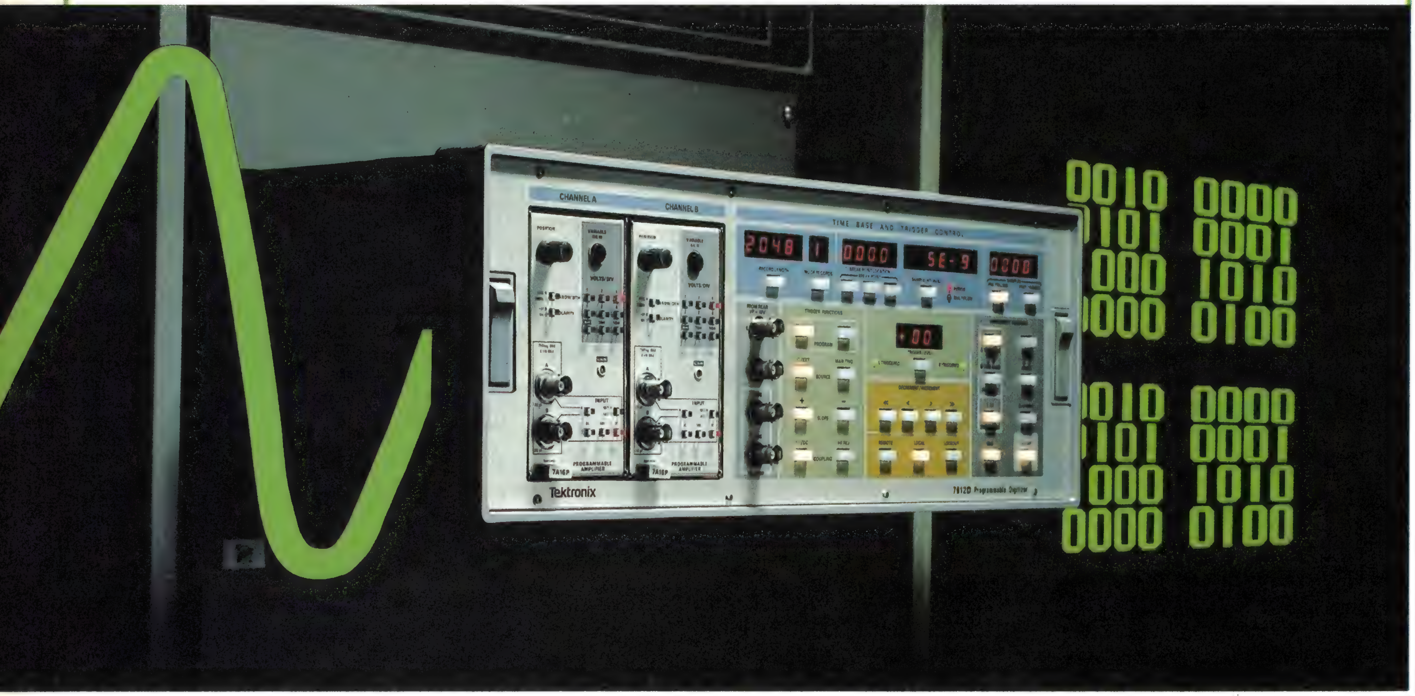
City____________________

State__________ Zip__________

Telephone____________________

CIRCLE NUMBER 24

Capture fast waveforms accurately with a 2-channel programmable digitizer



The challenge of recording high-speed waveforms and providing the recorded information to a computer for detailed analysis has been met by a programmable instrument that looks like a 5-ns, 32-k memory (16 k per channel). Breaking through existing barriers to digitizing fast signals, the 7612D resolves 8-bits at a top sampling rate of 200 megasamples/s and achieves an overall accuracy exceeding 7.8 bits at 300 kHz and 6 bits at 20 MHz. Until now, the best available sampling rate at 8 bits—with no guarantee of high accuracy—was 100 megasamples/s.

The 7612D contains two independent channels, with input signals routed through standard 7000-series plug-ins (Fig. 1). The plug-ins provide the signal drive for the digitizer—a real-time leading-edge design based on a CRT and an electron-bombarded-semiconductor target (see "Inside the world's fastest 8-bit ADC").

Currently, one plug-in, the 7A16P, is fully programmable. All functions can be set up under computer control via a mainframe IEEE-488 connector.

Sampling rate is selectable from 5 ns to 1 s per sample, with many intermediate steps available, or it is selected via an external clock. Trigger-signal "arming" is very flexible; for example, one mode allows cross-channel arming that prevents channel B from arming until channel A has started.

In a fast digitizer, eight bits is a good compromise between speed and resolution. At full sampling rates, each channel can store 2048 8-bit words.

The all-digital time base in each channel provides the appropriate digitizer strobe signals and memory-clocking lines. Not only that, but each time base can change sampling rates without any ambiguity during the recording process, as well as enable the instrument to function as a time-interval counter (with appropriate software). In the first case, recording rate can change as many as 13 times during a recording period (Fig. 2).

Note in Fig. 2 that the "real-time" signal has a pair of very fast responses separated by relatively large time windows. Since high-speed memory usually comes at a premium, it makes sense to record only the data of value and to concentrate the available memory capacity in the highest-resolution modes. Note also that the time-base frequency has been altered several times (under program control) to expand those areas of interest. Information as to

---

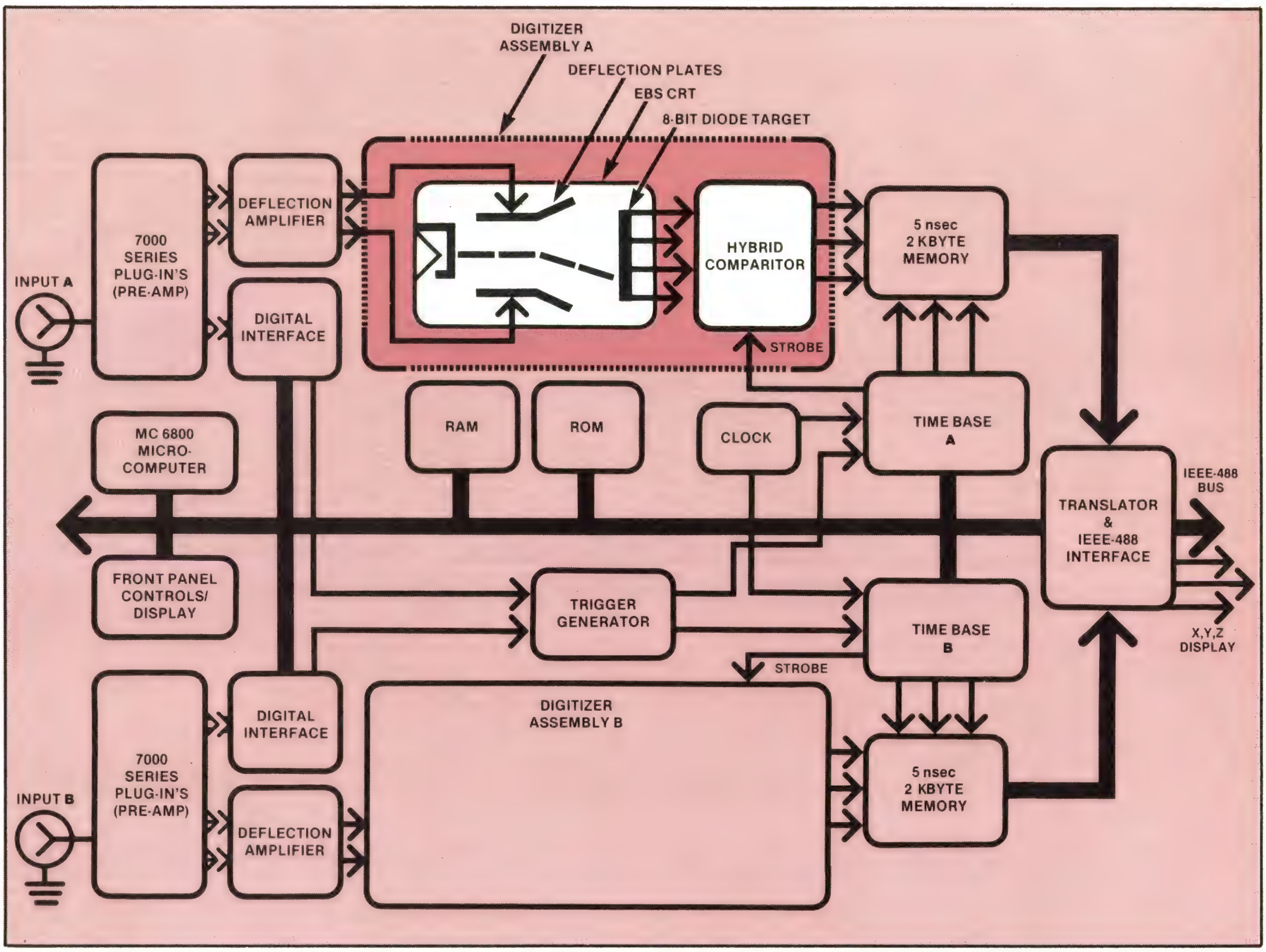
Neil A. Robin, Engineering Manager, Signal Processing Systems, **Bob Ramirez,** Applications, Tektronix, Inc., P.O. Box 500, Beaverton, OR 97077.

which waveform was recorded at what speed is relayed to the computer for reconstruction.

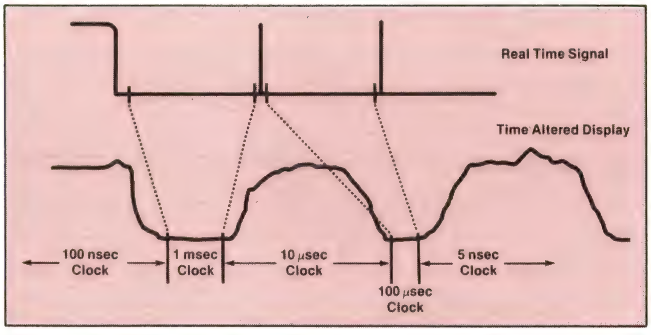
Combine the various time-base possibilities and the ability to examine an arbitrary signal-crossing point on the vertical axis, and the result is relatively high-precision time-interval counting (Fig. 3). Overall time-base accuracy is ±35 parts per million. When combined with pre-triggering, these techniques are particularly useful for calibrating waveforms in computers and avionics equipment.

In addition, the time base can reduce record size to less than 2048 words. This helps, say, with recording at high speed several events that occur much too quickly for normal recycling and data transfer. With the 7612D, simply record as few as 256 samples, then get ready to accept the next trigger pulse for further recordings. As a result, data transfer is postponed—very beneficial in burst transmissions and other rapidly occurring events.

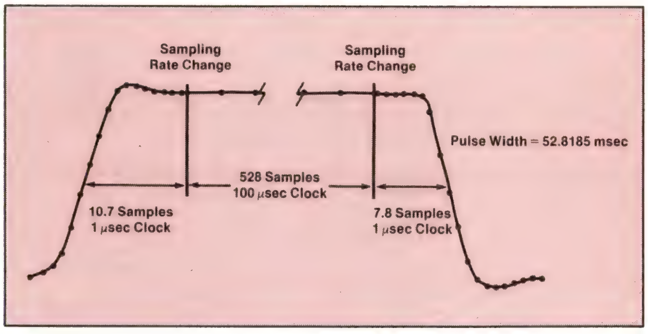
Moreover, the digitizer can align the trigger point



1. A two-channel digitizer aimed at system applications samples at 200 megasamples per second and offers a total memory capacity of 4096 8-bit words. Because no commercial 8-bit a/d converter was fast enough, the digitizer uses a novel technique to convert signals—a CRT combined with a special monolithic target.



2. Time-base breakpoints expand selected sections of an incoming signal. Up to 13 breakpoints can be called on to maximize use of internal memory capacity.

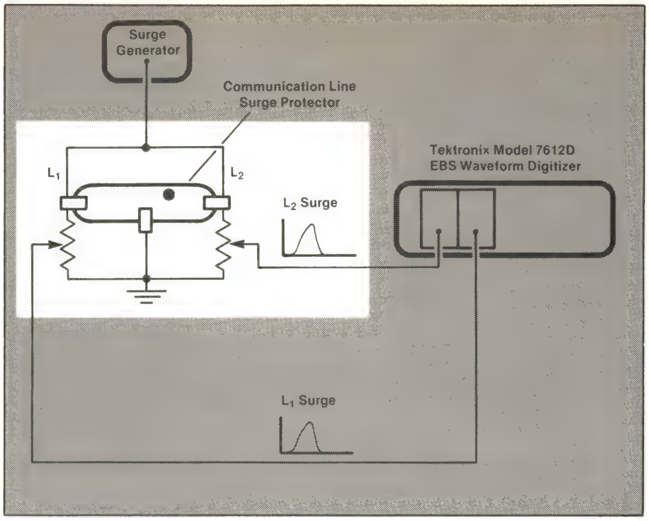


3. With breakpoints and a small software routine to detect an arbitrary trigger point, it is possible to obtain timing measurements that approach digital counter accuracy.

on any integer, in an eight-sample block anywhere from the beginning to the end of the record. This allows full pretrigger waveform viewing, full post-trigger viewing, or intermediate steps. Trigger signals require 20 least-significant bits (LSB) when the internal mode is used, with the unit triggering on signals up to 100 MHz. In addition, many trigger signal-coupling options are available, thanks to the 7000-series plug-ins.

The instrument's memory design is unique. Since an 8-bit, 2048-byte, 5-ns memory is not available in integrated form today, an equivalent memory is synthesized with slower devices and a high-speed front-end shift register. Larger, 20-ns memory is available, so the signal is multiplexed from the CRT into four rows of this storage. Consequently, the effective speed of the memory reaches a 5-ns "write" cycle time. Straightforward demultiplexing brings the data back to usable form.

In addition, high-level instructions, accessible


Surge Generator
Communication Line Surge Protector
Tektronix Model 7612D EBS Waveform Digitizer
L₁
L₂
L₂ Surge
L₁ Surge

5. Using the dual-channel capability of the 7612D, you can capture simultaneous breakdown waveforms associated with surge application to a three-electrode, common-gas-envelope surge protector.

Time Base Commands

HEADER	ARGUMENT	DESCRIPTION
REC	<NR1>,<NR1>	Set the number and length of records.
SBPT	<N8>,<NR3> [,<N8>,<NR3>]...	Set breakpoint locations and the sampling interval for the segment.
CBPT	[<N8>[,<N8>]]...	Clear all breakpoints or the specified breakpoints.
LTC	L[EFT] R[IGHT]	Specify the trigger channel to be programmed or queried by subsequent trigger function commands (Also selects the trigger channel to be associated with the currently selected time base).
MODE	PRE,<N8>	Set to pre-trigger by n samples.
	POST,<N8>	Set to post-trigger by n samples.

Trigger Channel Commands

HEADER	ARGUMENT	DESCRIPTION
SRC	INT	Select internal triggering source.
	EXT	Select external triggering source.
SLO	POS	Set trigger slope to positive.
	NEG	Set trigger slope to negative.
LEV	<NR1>	Set trigger level.
CPL	AC	Set trigger coupling to AC.
	DC	Set trigger coupling to DC.
HFR	ON	Enable high-frequency reject trigger.
	OFF	Disable high-frequency reject trigger.

Data Transfer Commands

HEADER	ARGUMENT	DESCRIPTION
READ	A[,REC[,SEG]]	Read Data from channel A
	B[,REC[,SEG]]	Read Data from channel B

4. Rigid adherency to the latest IEEE-488 standards has been followed in the instrument commands, along with new soon-to-be-approved standards for codes and formats. The IEEE-488 interface has been widely accepted as a hardware standard, but it still lacks software formats and protocol standards.

Inside the world's fastest 8-bit ADC

By performing high-speed real-time digitization, the 7612D offers an advantage not to be attained by the two other usual digitizing approaches, scan conversion and equivalent-time sampling—single-shot, full-pretrigger data recording. This proves a big help when events are unpredictable, as in failure analysis.

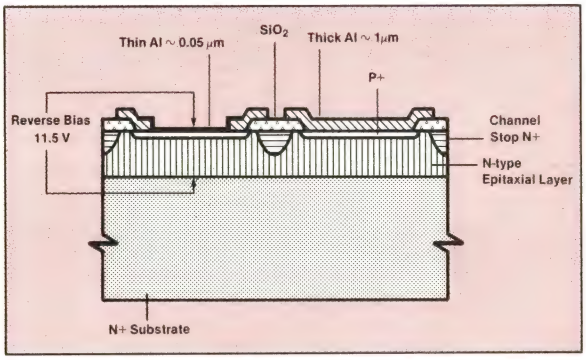
A real-time instrument continually digitizes the analog signal and stores the results in memory, usually solid-state. As memory fills with data, new data are systematically written over the old. At any given instant, the memory contains all previously recorded data—it has historical or pretrigger information.

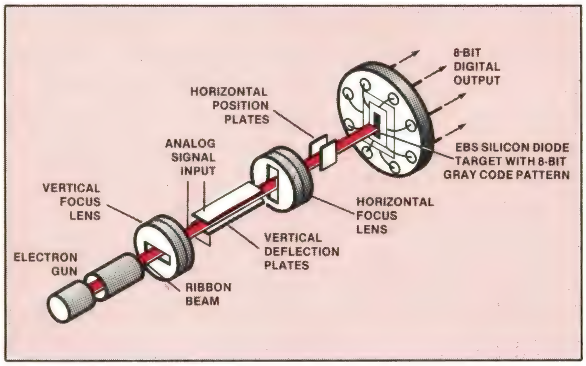
Anyone who has had a piece of equipment fail intermittently knows the value of pretriggering. For one thing, time-related signal data can be stored as an identified failure condition approaches. The trigger (failure) can be totally unpredictable. Of course, most digitizers in this class also provide for more conventional post or mid-screen triggering, useful for observing events surrounding the trigger point.

One of the main problems in implementing a high-speed real-time digitizer is to realize high sampling rates along with good resolution. The 7612D's solution: Combine a CRT with an electron-bombarded semiconductor (EBS) target.

Why get so exotic?

In any parallel digitizer, the frequency components of the least-significant bit (LSB) can build up very rapidly to tremendous values. For example, in digitizing a 10-MHz sine wave to 8 bits with a half-scale amplitude signal, the frequency of the LSB at the waveform's zero crossing will be about 1 GHz. To reach that speed with high resolution is extremely difficult with solid-state technology. The EBS technique can provide the gain necessary to sense extremely fast signals.





The above figure shows the internal construction of the CRT and the Gray-code target. Any discerned similarity to a conventional CRT fades very quickly with the discovery that there is no phosphor screen. Notice that the electron beam is focused into a ribbon (not the conventional small dot or point) approximately 0.040 in. wide by 0.0013 in. thick at the target end of the tube. Beam profile is altered by aperture slots on the focusing lenses. The input signal (23.5 V pk-pk) is applied to the vertical-deflection plates; the horizontal plates carry a static voltage, primarily for beam positioning.

The EBS target (above) is a monolithic IC, about 250 × 40 mils (20 × 230-mil active area), processed with a metalized mask to provide a diode array in the form of an eight-column Gray-code pattern. Each position of the electron beam corresponds to a unique code on the target. The beam is wide enough so all eight columns are addressed at any reasonable position of the vertical-deflection system.

Why Gray code, instead of binary? Because only one bit changes state for each incremental change in quantizing level, thereby avoiding coding ambiguity and nonmonotonicity. Once information is recorded in memory, it can be converted back to binary at a leisurely pace by slower logic.

Use of Gray code does not cause any penalty in the number of needed bits. All the diodes in each column are tied together by metalization, providing eight signal lines that exit the CRT, but with 256 quantizing levels represented.

Two-thickness metalization forms the windows on the EBS target. As shown in the figure, a very thin layer, about 0.05 μm, provides a return path for current flow and access to the pn junction by the electron beam. When electrons with about 10 kV of accelerating potential strike the thin metal, they pass through it and head towards the junction area. The resulting diode current totals about 2000 times that of the electron flow, because secondary hole/electron pairs are released by bombardment of the reversed-biased target.

The output level of the target diode is a very impressive 250 mV into a 50-Ω load. Since the LSB has an extremely high-frequency component—often exceeding 2 GHz—producing large-amplitude wideband signals at these frequencies is no small feat. The output is so broadbanded that very short leads are a must to transfer the eight signal lines to proprietary hybrid comparator circuits—in fact, the comparators are integrally fastened to the outside of the CRT. Only digitally latched data, updated at a "modest" 5-ns rate, come out of the CRT assembly.

Signal coupling occurs after the digitization process, so no front-end sampler is needed. It is far easier to design a high-speed digital comparator than an analog one with a refresh rate of 200 megasamples per second.

through the IEEE-488 interface, make the unit easy to use (Fig. 4). To ensure GPIB compatibility, the unit follows all currently accepted 488 coding and formatting standards. Of course, any system-based product like the 7612D relies heavily on the choice of fore, has been put into an operating system designed for applications in waveform-signal analysis (Tek SPS Basic).

In its system configuration, the 7612D is supported with checkout software that runs on two computer families, the DEC PDP-11 and Tek 4050 Series. All checkout occurs through the IEEE interface. Completing the picture are over 30 diagnostic messages, useful in system integration.

Many applications demonstrate the power of the 7612D programmable digitizer, but one—testing three-electrode, common-gas-envelope surge protectors—illuminates its capabilities. These devices, often found on balanced-pair communications lines, protect equipment and personnel from overvoltages, be they from equipment malfunctions, power-line crosses, or lightning-induced transients.

Fig. 5 shows a test setup for a three-electrode protector, in which a capacitive-discharge surge generator applies a high-voltage transient to each line connection of the protector. The dual-channel capability of the 7612D proves an advantage because it allows

Measuring ADC performance

A/d converters have always suffered from specsmanship, with almost as many ways to measure performance as there are vendors. But the principal problem in measuring performance is the reference signal: How precisely can it be predicted? Is the test truly dynamic in nature?

In the 7612D, performance tests keep several key considerations in mind:

- Computerize whenever possible to speed up results—provide unattended measurements.
- Use commonly available test equipment and fixtures.
- Minimize human interpretation—strive for go/no-go decisions from the computer.
- Log the results for future reference.

One simple technique meets all these criteria in principle: providing a high-quality analog sine wave to the digitizer input at various test frequencies (see Fig.). Narrow-band filters ensure that harmonic and noise components are reduced to an insignificant level before signal application.

Digitized results from the unit under test go to the computer via the IEEE-488 bus. Software, taking over at this point:

- Finds the best nonlinear, least-squares sine wave fit to the incoming digitized data. Trials are taken with changes in frequency, amplitude, dc offset and phase.
- Quantizes the input signal in the computer, simulating perfect digitizer response.
- Compares the actual digitized data from the unit under test with the digitized "best-fit" response.

Comparison is made on the basis of the following equation:

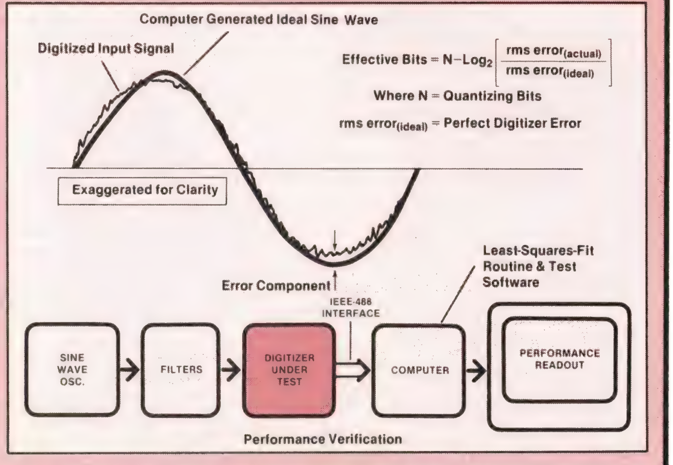
$$\text{Effective bits} = N - \log_2 \frac{\text{rms error (actual)}}{\text{rms error (ideal)}}$$

The 7612D accuracy specification, six bits at 20 MHz with a half-scale signal amplitude, is based upon this test. Those who rarely measure sine waves may wonder if the test is valid for them. It is. To classify instrument performance, tests must be reliably reproducible. Although pulse-parameter measurements form the more important class, sine waves are relatively easy to create, have a very predictable dv/dt and are bidirectional.

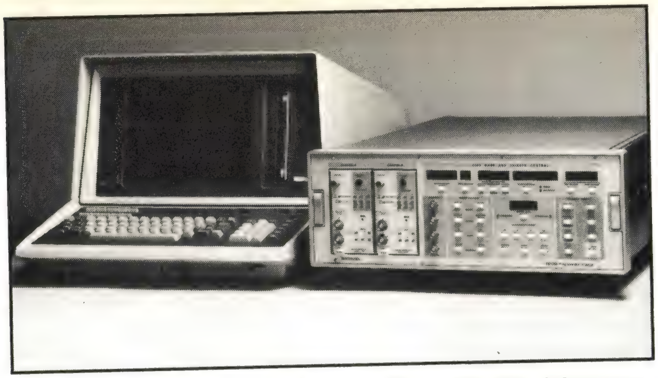
With a "standardized" pulse for performance measurement, there's always the nagging question: How predictable is that pulse? High-precision pulses are very difficult to guarantee. But today's digitizers need that precision—they often have accuracies that equal or exceed those of an oscilloscope. Eyeballing a waveform on the scope simply doesn't take the place of reproducible testing techniques.

Another way of expressing performance, based on the outlined test, is by signal-to-noise ratio. An ideal digitizer with a full-scale signal will have an s/n of (6N + 1.8) dB, where N = resolution in number of bits. Note that this test does not consider the dc offset drift of the system, which can be measured by comparing a known dc input voltage with the output.

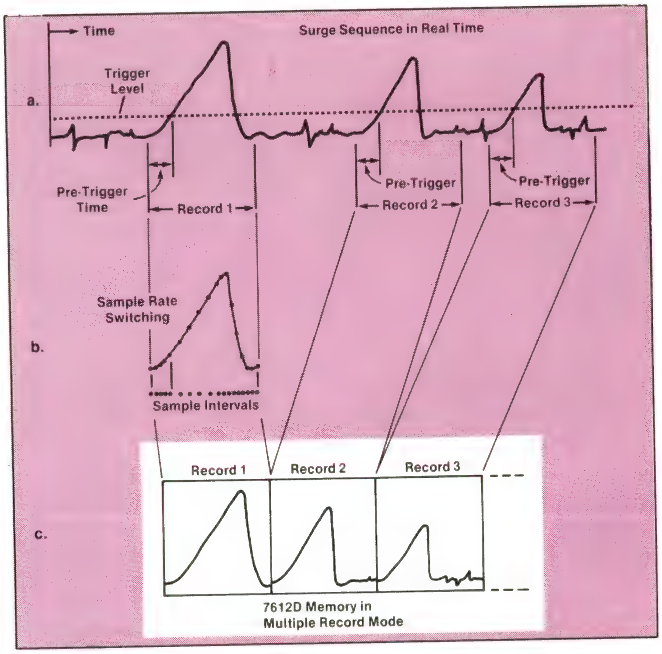
One of the obvious advantages of a system-oriented product is the ability to perform periodic self-test and calibration. With IEEE-488-interfaced signal generators and appropriate signal switching (multiplexing), system-calibration information can be logged so that measurement results can be corrected for system errors. This technique, commonly called auto-cal, offers some interesting possibilities for future instrumentation systems.


Computer Generated Ideal Sine Wave
Digitized Input Signal
Effective Bits = N−Log$_2$ [rms error$_{(actual)}$ / rms error$_{(ideal)}$]
Where N = Quantizing Bits
rms error$_{(ideal)}$ = Perfect Digitizer Error
Exaggerated for Clarity
Error Component
Least-Squares-Fit Routine & Test Software
IEEE-488 INTERFACE
SINE WAVE OSC.
FILTERS
DIGITIZER UNDER TEST
COMPUTER
PERFORMANCE READOUT
Performance Verification

Measure digitizer performance with a nonlinear, sine-wave, least-squares-fit routine. This method requires relatively straightforward test equipment and minimum-skill operators, which is good since the setup must be very repeatable and trustworthy. What's more, very little interpretation is needed since the final result is displayed in numerical form.



Because the 7612D is GPIB controllable, digitized data can be analyzed as desired by an external computer.



6. Numerous 7612D modes provide a variety of acquisition possibilities. In the surge sequence (a), the trigger level is set to ensure stable triggering; and pre-trigger time to capture the entire leading edge. Sample-rate switching (shown in b with far fewer samples than normal) can increase time resolution in selected areas; and memory division captures rapid sequences of events (c).

Calculating s/n and accuracy

It is well known that even an ideal a/d converter exhibits noise because of the quantization error inherent in the conversion process. This root-mean-square noise is found by

$$\text{rms error} = Q/\sqrt{12},$$

where Q is the quantum or value of the least significant-bit.

The signal-to-noise ratio of an ideal N-bit digitizer can be found from the ratio of the rms signal to the rms noise. For a full-scale sine wave,

$$\text{Ideal s/n} = \frac{\text{rms (signal)}}{\text{rms (error)}}$$

$$= \frac{2^N}{2} \bullet \frac{\sqrt{2Q}}{2} \Big/ \frac{Q}{\sqrt{12}}$$

$$= \frac{2^N\sqrt{6}}{2} \qquad (1)$$

Or, in dB,

$$\text{Ideal s/n} = 20 \log \frac{2^N\sqrt{6}}{2}$$

$$\approx 6N + 1.8.$$

If a real digitizer presents an actual signal-to-noise ratio of s/n, its performance can be expressed in terms of the performance of an ideal digitizer with N_1 effective bits of resolution. The value of N_1 is derived as follows:

$$\text{Actual s/n} = \frac{2^{N_1}\sqrt{6}}{2} \qquad (2)$$

Combining Eq. 1 and 2 gives the value of N_1:

$$N_1 = N - \log_2 \left(\frac{\text{rms error (actual)}}{\text{rms error (ideal)}} \right)$$

Consequently, an 8-bit digitizer with a measured s/n of 43.8 dB actually performs as an ideal 7-bit digitizer.

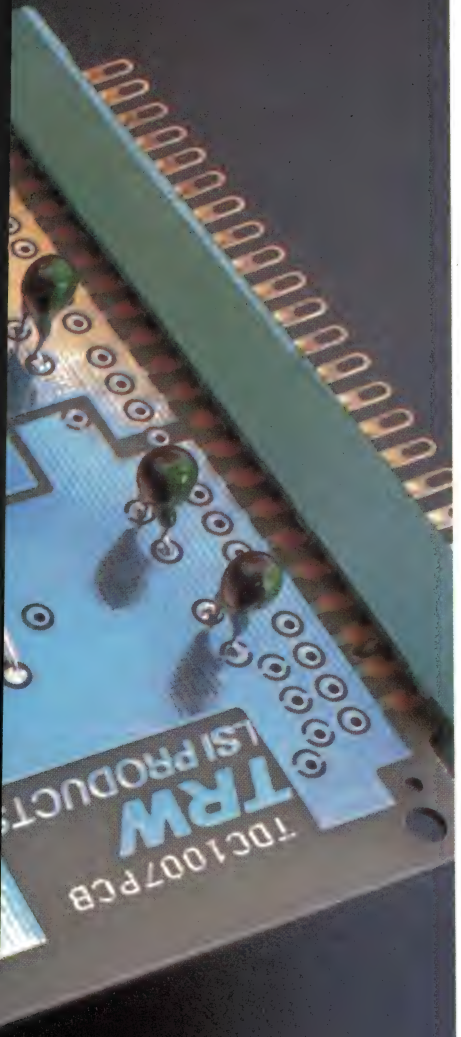
simultaneous capture of the clamping activity from each line terminal to the ground terminal.

This is crucial for several reasons, one being that the voltage at which breakdown occurs for each terminal is an important parameter. In addition, any differences between the waveforms from each terminal should be determined since major differences can give rise to major line-to-line overvoltages. Indeed, since heating can change surge-generator characteristics from shot to shot, and residual ionization can change protector reaction from shot to shot, simultaneous acquisition of each terminal's breakdown activity for each supplied surge becomes a virtual necessity.

Another 7612D feature, pre-triggering, enhances measurements further (Fig. 6) and ensures that the entire leading edge is captured without risking the instabilities of low-level triggering. Sample-rate switching is used to provide the greatest time resolution where needed. In addition, it is often useful to test protection capabilities for repeated surges that might arise, for example, from a quick succession of lightning strokes. The multiple-record-length capability of the 7612D allows acquisition of such rapid successions of events. Up to eight surges per channel can be captured before the digitized waveforms must be transferred out to either peripheral storage or to an external processing unit.

Since the 7612D is IEEE-488-compatible, interfacing to a variety of GPIB controllers or minicomputers is a standard operation. This makes it very appealing to transfer digitized waveforms to a minicomputer, where appropriate software routines can provide quick, accurate, in-depth analyses. For example, the surge waveforms from each protector terminal can be subtracted to get line-to-line voltage. In addition, the surges can be differentiated to provide wave-front rate of rise, and either integrated for contained energy or analyzed further by the software.■■

TRW
TRW
TRW
1
TRW
TRW
1
TRW
1



This monolithic 8-bit, 33 nsec A/D converter has everything

(And a test board to prove it.)

We've been told that the spectacular specs of our newsmaking TDC-1007J A/D converter are almost unbelievable. So we're making a "show me" offer that will make a believer out of every digital-thinking designer.

Order our monolithic 8-bit 33 nsec A/D converter on its own standard 3½"x4½" evaluation board (TDC-1007PCB). Fully assembled and tested, equipped with a 44-pin edge connector. Using +5V and ±15V power supplies, the board accepts and digitizes a 1-volt peak-to-peak signal from a 75-ohm source—at up to 30 megasamples per second.

Use it for performance evaluation of the converter. For system prototyping. As a test fixture. Price for 8-bit converter and board: $845. (Only $585 in 100s.)

Or if you prefer, deduct a hundred bucks and order our beauty by itself. Order just the converter (TDC-1007J), in an industry standard 64-pin DIP. (Only $485 in 100s.) We'll send along our data sheet/application notes to help you do your own thing.

Either way you go, you've got the TRW advantages: Up to 10-1 power reduction over other video-speed A/D converters and more than two-thirds size reduction. Conversion with unmatched accuracy at up to 30 megasamples per second. Highest reliability and stability over an indefinite time span. Wide temperature range performance.

Using the TDC-1007J is simplicity itself. A convert signal strobes 255 comparators, encodes all their binary outputs into an 8-bit word, and stores the word in an output latch. Unlike other types, our converter needs no sample-and-hold circuit. It works as a *flash converter*—doesn't depend on tedious successive-approximation techniques.

Either on the board or by itself, these products are now in stock at Hamilton/Avnet.

For immediate information, call 213/535-1831 or send in coupon.

TRW LSI Products
An Electronic Components Division of TRW Inc.
P.O. Box 1125
Redondo Beach, CA 90278

Please send data sheets on the **TDC-1007PCB** and **TDC-1007J** 8-bit A/D converter.

Name

Company

Div/Dept Mail Code

Address

City

State Zip

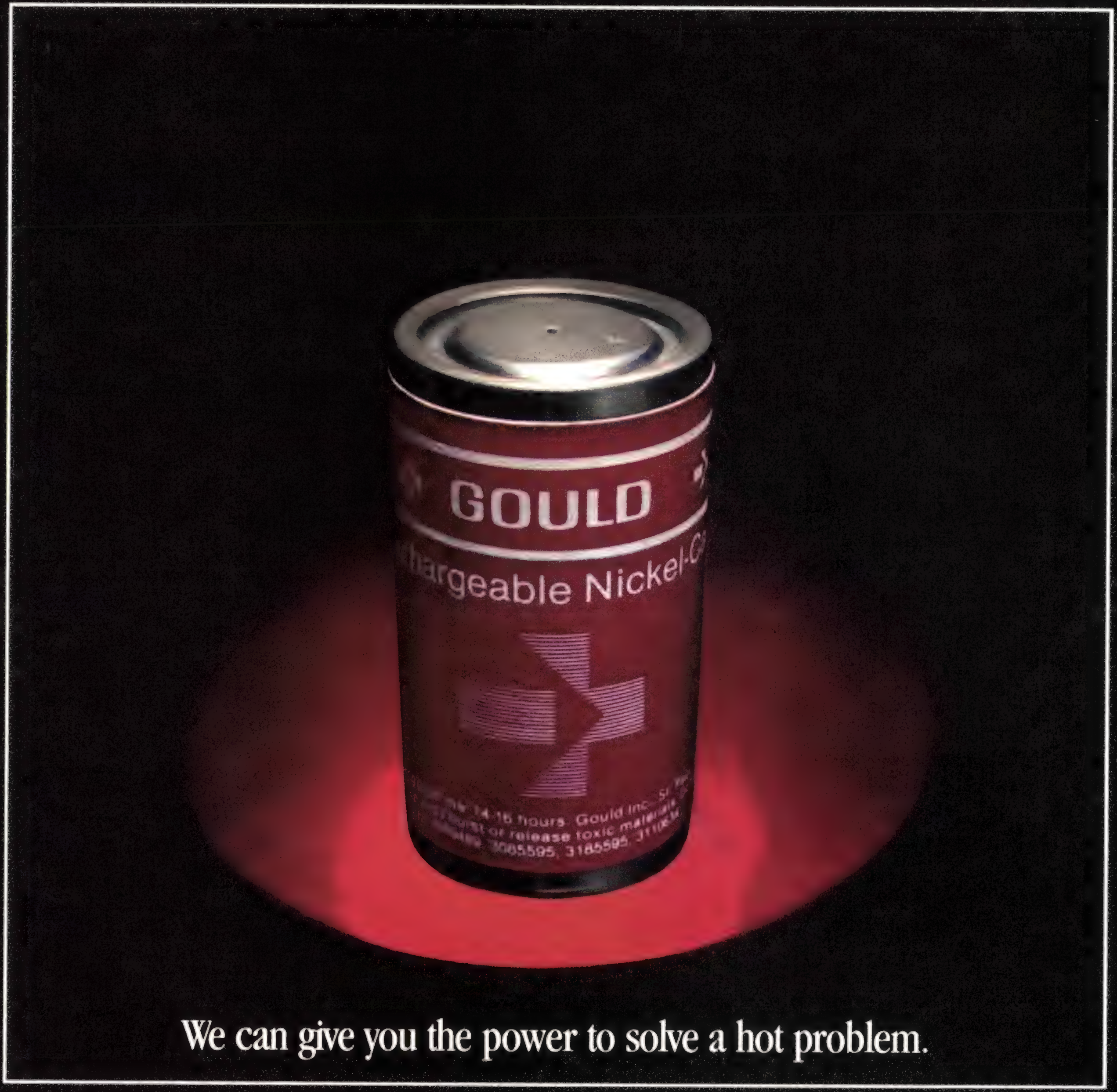
ED-2

TRW keeps you ahead in digital signal processing

TRW LSI PRODUCTS

ANOTHER PRODUCT OF A COMPANY CALLED TRW

CIRCLE NUMBER 25



Heat is a rechargeable battery's biggest enemy. At about 45° C life starts to shorten dramatically. The new Polytemp™ is a NICAD® nickel-cadmium battery designed to take the heat and give long life. Satisfactory life to 70° C.

Polytemp's long life in high temperature applications makes it an ideal battery for backup power in memory circuits, emergency lighting and alarms, telephone and telegraph equipment, electronic instruments and process control equipment.

And Polytemp batteries have a unique negative electrode construction which means less voltage depression during overcharge than sintered nickel matrix types. A radial compression seal gives greater protection to surrounding circuits.

A battery that leads a hot life doesn't have to lead a short life. Now there's Polytemp from Gould. The company that makes more different types of batteries than anyone else in the world.

Available in sizes "½AAA" to "F." (0.070 amp. hours to 7 amp. hours.) For complete design spec's write:
Applications Engineering Mgr.
Gould Inc.
931 Vandalia St.
St. Paul, MN 55114

GOULD
An Electrical/Electronics Company

CIRCLE NUMBER 26

New challenge in component testing: Putting a codec through its paces

Most tests that have appeared for monolithic codecs are applicable to the codec only as part of a larger, telephone system. For testing the codec directly, the most cost-effective and readily accessible approach takes advantage of existing digital test systems: Hardware modules capture the data from the codec in digital form (Fig. 1) and software modules reduce the parameter tests to mathematics (from the time domain into the frequency domain). With its 1-MHz test rate and 160-ps timing resolution, the system can test all of the digital parameters of codec devices in less than 10 seconds (typically), a satisfactory speed at the anticipated volume of testing.

The codec (coder/decoder) accepts a nondigital signal in the form of free human speech and converts it to a digital data stream. Also, as its full name implies, the same device can reverse the process—accept a digital data stream and convert it to a nondigital speech waveform, which is understandable by humans. Once the information in a telecommunication operation has been transformed to the digital domain, it is processed by digital functions, which must be tested for reliability.

A codec may be viewed either as a half-channel device or as a full-channel device. The term half-channel refers to the partitioning of the device as an encoder and decoder. A test of the device in this case treats it as two independent functional entities. The full-channel view considers the encoder and decoder to be tied together. Because it offers limited access and the possibility that errors will cancel each other, the full-channel approach has much less merit for testing.

In addition to the classic device parameters (such as input thresholds and leakages and output source and sink capabilities), tests of the codec must handle three unique parameters: signal-to-distortion, gain tracking and idle-channel noise.

The testing problem posed by the signal-to-distortion parameter of the codec is the requirement for a highly accurate signal synthesizer and filter and for the mathematics to arrive at dB units. The test for the encoder must deliver a given signal into the analog pin, detect the serial digital output and, by filtering-out the input-signal component, arrive at the distortion value. The decoder is tested with digital input and analysis of the analog output.

The gain-tracking parameter is measured in a similar manner as the signal-to-distortion parameter. The primary difference is that the device's output, whether it is digital (for the encoder) or analog (for the decoder), is converted for signal magnitude. Also as the name implies, the measurement must be performed for many values of inputs, since the desired final result is the linearity of the gain as the input varies. Good linearity ensures that softly spoken, calm speech on the telephone can be understood as accurately as a loud, angry transaction.

Finally, in testing the idle-channel noise parameter, the environment must be very "clean", or noise-free. For this test, the input pin is terminated and the output is measured for signals in the frequency band from 300 Hz to 3 kHz, typically. The magnitude is about −75 to −80 dBm. In terms of absolute noise voltages, this represents a scale of 10^{-4} V. The test system and the device interface fixture must have no more noise than 10^{-5} V.

Testing codecs with hardware

The digital test systems on which solutions to the codec testing problem are developed are widespread in the industry. One version, the Fairchild Sentinel, is found in production applications and another, the Sentry VII, in an engineering environment. Because both systems have been in existence for years with consistent evolutionary enhancements, they present none of the risks of "paper tiger" systems.

Testing the input and output of the codec requires hardware for stimulating the chip. In decoding, a synthesized sine wave is the input signal. In encoding, a waveform generator provides the required analog input signals.

In Fairchild's digital test system, the waveform generator is formed with:

- A Sequence Processor Module (SPM) which generates 60 bits of random digital data of almost unlimited depth (Fig. 2)
- A high-speed digital-to-analog converter (DAC) which accepts the data generated by the SPM

Keiji Muranaga, Technical Director, and **Marc Loranger**, Staff Engineer, Fairchild Test Systems Group, 1725 Technology Dr., San Jose, CA 95110.

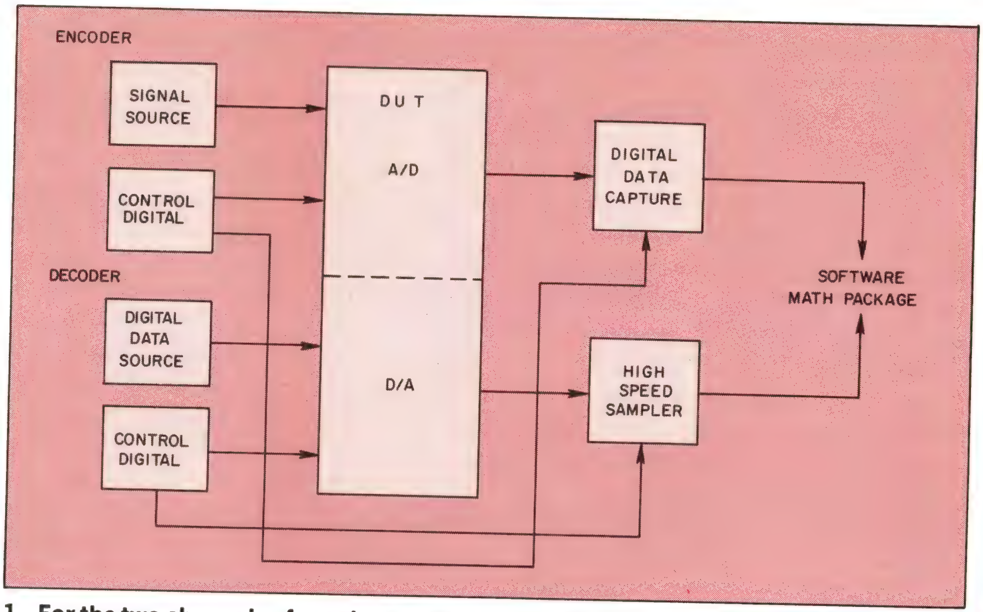
- A programmable attenuator which regulates the analog signal from the DAC.

Together, these instruments provide an extremely accurate waveform of any type required. The frequency components of the input signal are completely controlled; this control is especially important in the preferred of the two methods for testing a codec. The first method depends upon a "perfect" sine wave, typically between 1.004 and 1.020 kHz, as input; the second uses a band-limited noise signal of 100-Hz width, around 500 Hz.

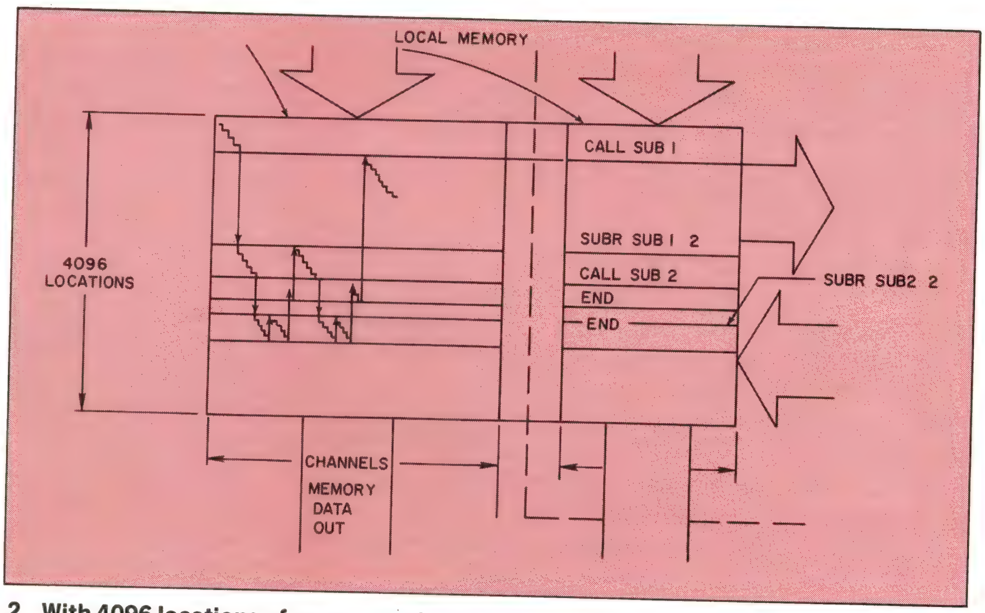
Of the two, the second method is preferred by the telephone industry because it more accurately represents speech waveforms and avoids leakage between frequency bins, which is a common problem in discrete-Fourier analysis of an analog signal.

The frequency components of the input signal, either analog or digital, must contain only those components which fall in the frequency bins of the Fast Fourier Transform (FFT) or else the mathematical filtering algorithms become very complex. With the SPM, complete control of these parameters is inherent.

For measuring output, the solutions all reduce to spectrum analysis of one sort or another. A spectrum analyzer may be implemented in the time domain (with the use of filters and voltmeters) or in the frequency domain (with the use of a high-speed



1. For the two channels of a codec, two different signal inputs—an analog signal for the encoder and a digital data stream for the decoder—are supplied to the device under test, and the resulting output is examined for accuracy by the test software.



2. With 4096 locations of memory at its disposal, the sequence-processor module can produce 60 bits of random digital data of almost unlimited depth.

sampler tied to a math package).

In the case of the encoder, the sampler is actually the device under test (DUT), and the digital output-data stream is strobed into the computer and analyzed. Reconverting the output to the analog form with an "ideal" decoder is not recommended.

For the decoder, the output is strobed with the high-speed sampler. The accuracy of the sampler is approximately 16 bits (Fig 3). The output of the sampler is transmitted to the computer and analyzed by the CPU in the same way that the output of the encoder is analyzed and then tested against limits.

Testing signal-to-distortion

Either the sinusoidal signal or band-limited noise signal method may be used, for example, in testing the signal-to-distortion parameter. A third method—static testing—is not fully developed. When a digitally synthesized sine wave is the input signal, a frequency of approximately 1.02 kHz is generated to synchronize completely with the sampling frequency used in the time-to-frequency domain conversion. The filter is a mathematical one.

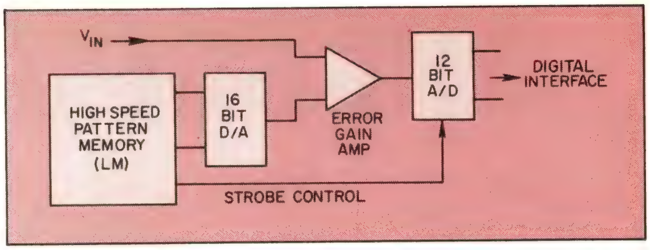
For the encoder, the hardware converts the serial digital output to parallel data, which the tester software linearizes prior to converting from the time domain to the frequency domain.

For the decoder, a high-speed sampler provides the output data to the computer for comparison against the programmed input digital data. Care is taken to prevent any foldback frequency from affecting the high-speed sampler and distorting the signal of interest. Foldback frequencies are that part of a signal beyond the bandwidth of the actual sample rate; they are, therefore, invalid.

This method has been shown to be superior to time-domain methods, which use hardware filters and an RMS meter to measure the distortion components. The new method works with variable frequencies and enhances throughput, since the mathematical data obtained in this test can be used in other parameter tests, such as gain tracking.

A second way to test for signal-to-distortion is by using the noise signal as input, with a frequency of 500 ±50 Hz. This method is less desirable only to the extent that it needs more hardware to generate the digital noise signal; namely, a 17-bit shift register with bits exclusively ORed and fed back. The analog input synthesis and output analysis of this noise signal may be performed with the mathematical package, as with the sine wave.

The third method is static testing the a/d and d/a response by determining the critical voltage values at which the converter makes its transition from bit to bit. This method involves a complex mathematical problem: relating threshold voltage values to distortion. Although some success has been reported in this area, agreement and acceptance has not been general enough for actual implementation.



3. The high-speed sampler (shown at the output of the digital/analog channel of the codec being tested in Fig. 1) contains its own high-speed pattern memory and d/a and a/d conversion capability.

Software modules address three basic areas: signal synthesis, Fast Fourier Transform (FFT) for signal analysis and mathematical routines to convert measured values to specified units for tests against limits. Precisions up to 48 bits are needed to obtain maximum accuracy and flexibility from the various calculation routines. The software is in the form of user-linkable overlays that can pass parameters, for minimum dedication to a given specification or a given device design.

Software modules are user-linkable

For signal synthesis, the software module performs the task of programming the SPM to produce the desired waveform. The software module can produce a different frequency with three or four commands. The signal synthesis routines (which work for either the encoder values or the decoder values) are totally synchronized to the FFT. This overcomes the previously mentioned limitation on the FFT (leakage between frequency bins). The accuracy of the SPM (less than or equal to 16 bits) is not at all limited by software, which can program up to 60 bits in depths exceeding 4096 bits at up to 10 MHz.

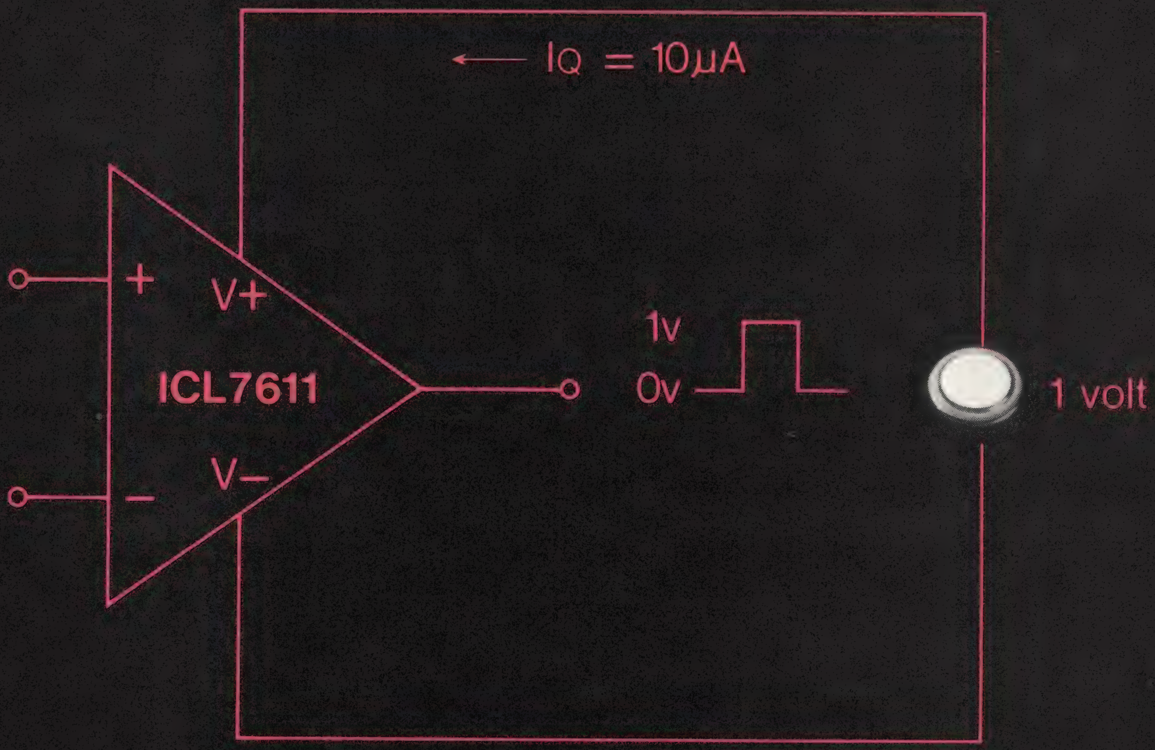
Software for the FFT applies to all of the transmission parameters, in what may be called voice-quality tests on the codec output. Specifically, the FFT package captures the digital data as they are sampled either by the encoder or the high-speed sampler. In the case of the encoder, it converts the nonlinear encoded data (μm law or A law) to linear form.

A Fast Fourier Transform algorithm performs a 512-point time-domain to frequency-domain transformation. The FFT package performs any required filtering in the frequency domain, such as a C-message for the weighed measurements and notch filtering for signal-to-distortion tests. Also, the FFT package is used to calculate and pass back the values of such transmission parameters as signal-to-distortion, absolute gain and harmonic distortion, expressed as dB or dBm.■■

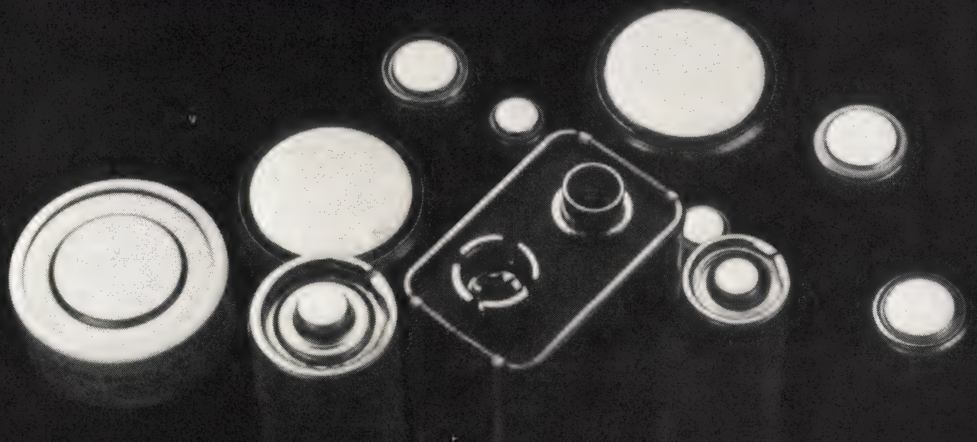
How useful?	**Circle No.**
Immediate design application	**544**
Within the next year	**545**
Not applicable	**546**

MICROPOWER CMOS OP

PICK YOUR POWER SUPPLY
±½v to ±8v



$V_S = 1$ volt
$V_{out} = 1$v PK-PK
$P_C = 10\mu W$



AMPS. FROM INTERSIL.

RAIL-TO-RAIL.

The ICL7611 family of ultra-low power CMOS operational amplifiers operates perfectly on a 1V supply. A single battery for instance. They require a fraction of the voltage of the bipolar OP AMPs you're using now. Yet, output swing is within millivolts of the supply rails. And they operate from ±½V to ±8V. Or, from a single +5V logic supply. What you get is low voltage operation with usable output swing.

LOW POWER.

If you're looking for low power, Intersil's delivering. In CMOS OP AMPs. In fact a whole family. Many with a unique quiescent current programming pin which can be set for standby currents of 10μA, 100μA or 1mA...with no external components. What you get is ultra-low power consumption: Down to 10μW. That means reduced power supply and cooling requirements.

LOWEST INPUT CURRENT OP AMPs.

1pA (Typ.). That's it. Compare that to the Industry Standard BiFET's 30pA requirement. High accuracy performance in high impedance applications. $10^{12}\Omega$ input impedance plus ultra-low noise current.

SINGLES. DUALS. TRIPLES. QUADS.

Right now, there are 11 versions in the ICL7611 family of CMOS operational amplifiers, including types with extended input common mode voltage ranges that go beyond both supply rails and others with input voltage protection of up to ±200V. Internally and externally compensated versions are also available. All have input currents of 1pA (Typ.).

TYPICAL PERFORMANCE.

@$V_S = \pm 5V$, 25°C

V_{OS}	3mV			
I_{OS}	0.5pA			
I_b	1pA			
A_{VO}	100 db			
CMRR	90 db			
PSRR	88 db			
I_Q — Programmable	10μA	100μA	1mA	(per channel)
Slew Rate	.016	.16	1.6	V/μs
Bandwidth	.044	.48	1.4	MHz

PICK YOUR SPECS.

V_{OS} specifications down to 2mV MAX. Full military temperature devices available (−55°C to +125°C). Pinouts compatible with Industry Standard OP AMPs. And, prices that start at 75¢ @100 pieces for singles...$2.55 for quads.

MORE THAN CMOS: MAXCMOS.™

The ICL7611 family of OP AMPS are manufactured using Intersil's proven MAXCMOS™ process. A process that delivers ultra-low power operation. That means ultra-cool performance that allows high density packaging. You get maximum reliability...from a proven process. And, you get to pick your power supply.

INFORMATION FAST.

Proof not claims. From your Intersil Sales Office or Franchised Distributor. Or, send us the coupon below. We'll send you back complete information on the MAXCMOS™ OP AMPs that operate on ±½V to ±8V supply...a single cell battery, for instance.

TM—MAXCMOS is a trademark of Intersil, Inc.

INTERSIL SALES OFFICES:

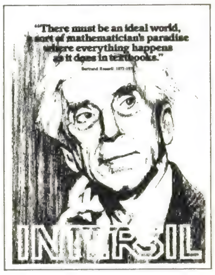
CALIFORNIA: Sunnyvale (408) 744-0618, Long Beach (213) 436-9261 • COLORADO: Aurora (303) 750-7004 • FLORIDA: Fort Lauderdale (305) 772-4122 • ILLINOIS: Hinsdale (312) 986-5303 • MASSACHUSETTS: Lexington (617) 861-6220 • MINNESOTA: Minneapolis (612) 925-1844 • NEW JERSEY: Englewood Cliffs (201) 567-5585 • OHIO: Dayton (513) 866-7328 • TEXAS: Dallas (214) 387-0539 • CANADA: Brampton, Ontario (416) 457-1014

INTERSIL FRANCHISED DISTRIBUTORS:

Advent (IND, IA) • Alliance • Arrow • Bell Industries • CESCO • Component Specialties • Components Plus • Diplomat (FLA, MD, NJ) • Harvey (upstate NY) • Intermark • Kierulff • LCOMP • Parrott • R.A.E. Ind. Elect. Ltd. • RESCO/Raleigh • Schweber • Summit • Wyle • Zentronics Ltd.

INTERSIL

Analog Products—Linear Circuits
10710 No. Tantau Ave., Cupertino, CA 95014
(408) 996-5000 TWX: 910-338-0228
(800) 538-7930 (Outside California)


"There must be an ideal world, a sort of mathematician's paradise where everything happens as it does in textbooks."
Bertrand Russell 1872-1970
INTERSIL

Gentlemen,

_____Send me complete information on your ICL7611 Family MAXCMOS™ OP AMPs.

_____While you're at it, send me your 20 x 24" Bertrand Russell poster.

Name _____

Company _____

Address _____

City _____

State _____ Zip _____

ED2180

ONE GIGAHERTZ
REAL-TIME BANDWIDTH

Tektronix 7104 Plug-In Scope

See what you've never seen before.

Now Tektronix proudly announces its new 1 GHz real-time scope, the 7104. Rise time: 350 ps. Plus a 10mV/div - 1V/div vertical sensitivity, and a 20 cm/ns writing rate so any signal, single-shot or repetitive, can be seen and photographed. A window into a world previously invisible.

As part of the Tektronix Plug-In family, the 7104 is compatible with 7000-Series plug-in units. Including several new ones that take the 7104 to the limits of its specifications. In addition, the 7104 opens a whole new world of technology, both in circuit design and crt operation.

Throughout the history of science, important discoveries have been made possible by similar advances in instrumentation. We believe the 7104 represents such an advance.

The Tektronix 7104 Plug-In Oscilloscope. See what you've never seen before.

Tektronix®
COMMITTED TO EXCELLENCE

For literature, call (800) 547-1512 toll free.

Signatures take a circuit's pulse by transition counting or PRBS—but watch those loops

Signature analysis—data compression used for detecting and locating faults in digital circuits—is usually employed by commercially available automatic test equipment in one of two forms: transition counting or pseudorandom binary sequence (PRBS). Each method has particular advantages and disadvantages, and knowing them will provide rough guidelines for determining which type of circuit fault each is better suited to detect. It will also show where signature analysis may be impractical—in feedback-loop circuits.

Transition-counting signature analysis, which first appeared in test systems offered by Data Test Corp. in 1970, is usually implemented with pattern-generation circuits to excite the circuit being tested. Pattern generators produce very long sequences, having as many as 1-million bits, and these tend to offer low error rates at observable nodes.

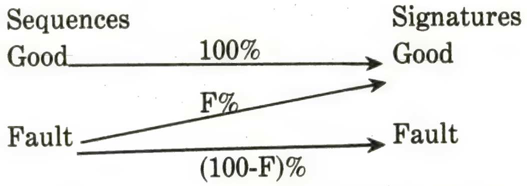
Count the signatures

Transition-counting signature generators involve a counter, whose content is the signature, and a transition detector that advances the counter when a change of state occurs in its input sequence.

With the counter initially set to zero, the detector may also be set to zero, so if the first bit of the sequence is a ONE, a transition is detected. Each subsequent bit of the sequence records a transition count if it differs from the previous bit (Fig. 1).

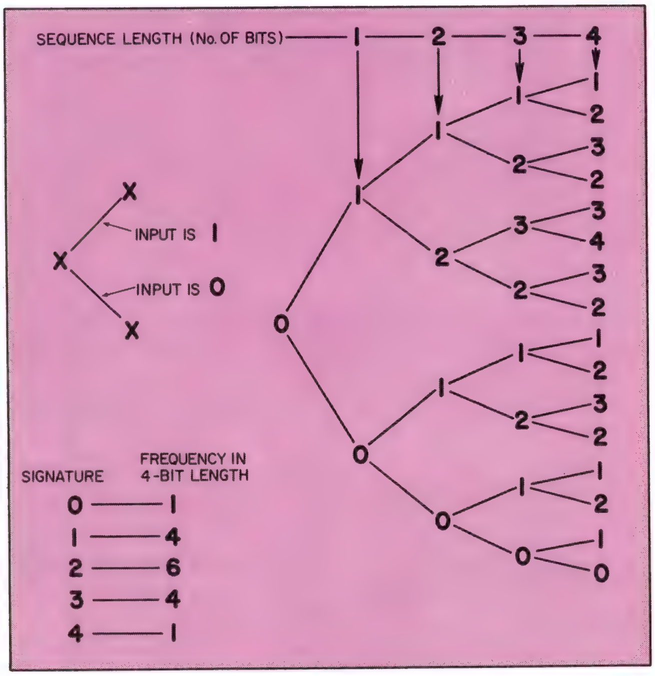
Reading down a column for a given length sequence provides all the signatures that can occur for that length. Clearly, data compression is taking place. The sixteen 4-bit sequences compress into five signatures, 0 through 4. Notice that most signatures correspond to more than one sequence; signature 2 is generated by six sequences. This grouping gives rise to fault-masking errors, from which all compression techniques suffer.

Although a sequence carrying fault information is different from that of a good circuit—it usually carries a different signature—it may fall into the same signature group as the good sequence. In that case, because signatures are being compared, the fault will go undetected.



As the diagram shows, F% of fault sequences will be mapped into the same signature as the good sequence and, therefore, go undetected. The value of F can be calculated if it is assumed that any of the possible sequences are equally likely candidates for the good and faulty sequences.

For longer sequences, however, the hazard of fault masking diminishes. As the following listing shows, short sequences tend to produce a few highly populated signatures (Fig. 1), which are more likely to catch both good and fault signatures, thus producing errors. Long sequences tend to produce more uniform grouping and less error.

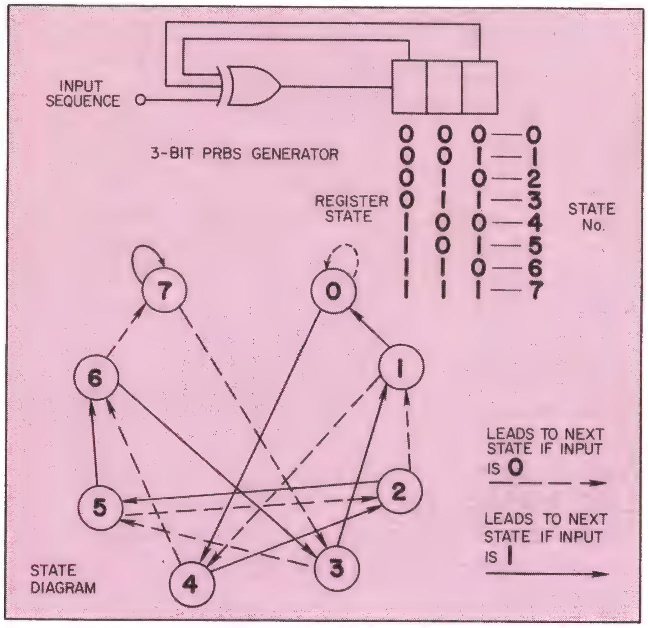


1. Four signatures are possible with a 4-bit sequence. Reducing the length to 3 bits allows three unique signatures. Note, however, that the frequency of occurrence is not the same for all signatures. Signature 2 leads the group with six occurrences.

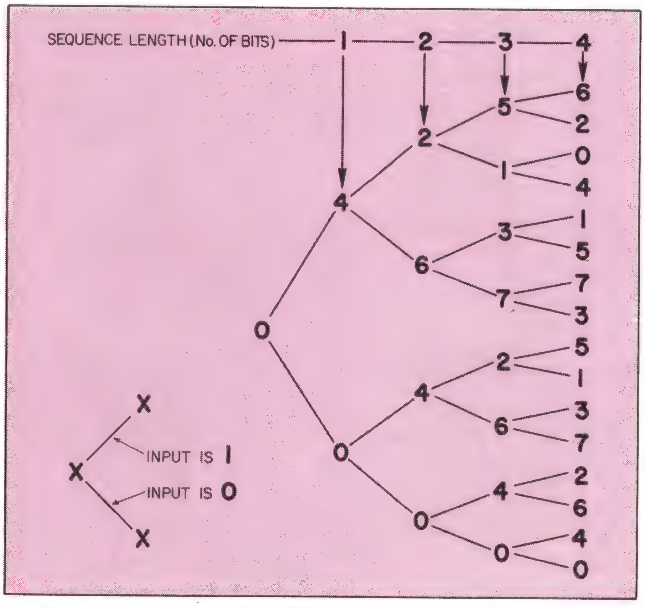
James K. Skilling, Staff Scientist, Advanced Development Group, GenRad, Inc., 300 Baker Ave., Concord, MA 01742.

Sequence length	% of cases in error
10	17.0
100	5.6
1000	1.8
10,000	0.6
100,000	0.2

These are two exceptions to the assumption that any sequence is equally likely as a fault sequence. Faults are accurately modeled by stuck nodes (always ONE or ZERO) in the microstructure of a circuit and this in turn often produces a stuck observable node. Therefore, expect the two stuck-node sequences—all ONEs and all ZEROs—to occur more frequently than other sequences.



2. This 3-bit version of the pseudorandom binary-sequence generator used in commercially available ATE helps reduce the probability of fault-masking errors.



3. The signature tree for a PRBS generator differs greatly from that used with a transition-counting generator: There is no compression until the sequence is longer than the register used to generate the sequence.

Not stuck on stuck nodes

Transition-counting methods do very well on stuck nodes because the two special sequences each have their own signature, ZERO and ONE, shared with no other sequence. Test designers go to great length to ensure that during a test all observable nodes show activity. Therefore, the transition counter should give very good coverage of stuck-node faults.

But what about those fault-masking errors?

In 1977, Hewlett-Packard introduced a product with a new type of data compressor that radically reduced the probability of such errors. The signature generator used a clocked shift register and an EXCLUSIVE-OR gate (see the simplified 3-bit version in Fig. 2). Since the generator circuit was almost like that for generating pseudorandom binary sequences, the circuit was named the PRBS generator.

If the simplified circuit is initially set to all ZEROs in the register, and a ONE input is applied, the gate will have a ONE output (the three-input XOR produces a ONE output only when one or three of its inputs are ONE). The next clock pulse will shift the gate output into the first stage of the register and ZEROs from preceding stages into the second and third stage, which leaves the register containing 100 in state 4.

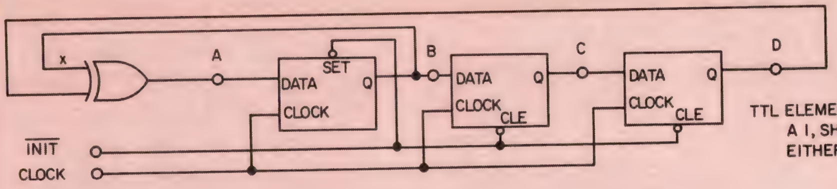
From the state diagram, the register contents—or signature—can be identified for all sequences, for 1 to 4-bit sequences. Fig. 3 shows coding but no compression until the sequence is longer than the generator register. For example, reading down the 3-bit sequence column reveals that each signature occurs only once. When the sequence is one bit longer than the generator, each signature appears twice. In general, there are $2^{(S-G)}$ sequences mapped into each signature, where S is the sequence length and G is the generator length.

Now the odds of fault masking can be calculated with, again, the assumption that the good and faulty sequences are both as likely to be any of the possible sequences of a given length:

$$F = \frac{2^{(S-G)} - 1}{2^{S} - 1} \simeq \frac{1}{2^{G}},$$

The approximation has negligible error (< 1%) for reasonable-length—$(S-G) \geq 6$—sequences. The chances of error for the PRBS generator are then very small and independent of sequence length. As indicated in the tabulation for the usual 16-bit-long generator:

Sequence Length	% of cases in error
10	0.0000
100	0.0015
1000	0.0015
10,000	0.0015
100,000	0.0015



TTL ELEMENTS–OPEN INPUT CREATES A I, SHORTED OUTPUTS ARE O IF EITHER OUTPUT IS O

Event no.	Good circuit	Node C stuck at 0	Node C stuck at 1	Open-clock center latch (looks like a buffer)	Open-gate input, internal at x	Short nodes A to D
	ABCD	**ABCD**	**ABCD**	**ABCD**	**ABCD**	**ABCD**
1	**1100**	**1100**	**$11\underline{1}0$**	**$11\underline{1}0$**	**1100**	**$\underline{0}100$**
2	**1110**	**$11\underline{0}0$**	**0111**	**0111**	**1110**	**0010**
3	**0111**	**1100**	**1011**	**1001**	**0111**	**1001**
4	**1011**	**1100**	**0111**	**1110**	**$\underline{0}011$**	**0100**
5	**0101**	**1100**	**1011**	**0111**	**0001**	**0010**
6	**0010**	**1100**	**0111**	**1001**	**1000**	**1001**
7	**1001**	**1100**	**1011**	**1110**	**1100**	**0100**
8	**1100**	**1100**	**0111**	**0111**	**1110**	**0010**

4. The closed-loop circuit is the greatest obstacle to signature analysis. To make the method work, the loop must be opened somehow.

However, the PRBS generator does not do quite as well as the transition counter on stuck nodes. The stuck-node signatures are shared with others and have the same odds as shown of fault masking—still very acceptable odds.

As for their ability to pick up fault-masking errors, often translated into "PRBS generators catch all 1-bit errors," beware of misleading implications. PRBS generators are linear in the sense that if two sequences are added to produce a new sequence, the signature of the new sequence is the sum of the signature of the sequences added. For the 3-bit generator, this is easily illustrated (recall that modulo-two adding is done without carry) and can be checked using Fig. 3:

Sequence	Signature
0111	101 (5)
0010	110 (6)
0101	011 (3)

If a zero-signature sequence can be found, then a fault-masking situation can be generated by adding it to a sequence—this will not change the signature, as ZERO is added to it, but will create a new sequence. For the 3-bit generator, the ZERO producing the sequence is 1101. After an initial ONE input, 101 is input to cancel the effect of the feedback from the shift register to produce ZEROs out of the gate, and eventually an all-ZERO register. The ZERO-producing sequence then depends on the number and connection of feedback taps on the register, and it characterizes a generator.

For the case of the 3-bit generator and 4-bit sequences, all fault-masking sequence pairs differ in the first, second, and fourth bit (1101 is added to one to produce its partner), that is, by three bits. The following listing summarizes the number of bits that can differ in good and fault sequences, the number of ways such differences can occur and the number of occurrences that produce fault-masking errors (errors will only occur when three bits are different and they must be the first, second, and fourth):

No. of bits different in good and fault sequences	No. of sequences that can have this difference.	No. of sequences resulting in error
1	4	0
2	6	0
3	4	1
4	1	0
	15	

In this particular case 1, 2, and 4-bit differences will be detected without error, but 25% of the 3-bit differences will be in error. The average error probability, without regard for the number of bits different, will be 1/15. The general case is more complex, for with longer sequences the zero-producing sequence can be added-in with various numbers of leading zeros at anytime to produce fault-masking partners.

In summary, there will be no fault-masking errors for good and faulty sequences that differ in one or a few bits, but the error probability will be high enough on certain other differences so that for all sequences the average probability is given approximately by $1/2^G$.

Stop, you're both wrong

Obviously, then, both signature-analysis techniques work effectively in certain situations—but there are also situations where neither transition counting nor PRBS is effective. They both work when the strategy is to diagnose faults by comparing observed and known-good sequences until a removable component or assembly is found that has good input sequences and bad output sequences. Faults can be traced from bad circuit outputs toward the input until the defective component is bracketed.

If, however, the output of a component is traced through the circuit and it loops around to affect its own input—as in circuits with feedback loops—then diagnosis by any method is difficult. A component failure in the loop will cause all the sequences in the loop to differ from the good ones—no good-input, bad-output component can be found.

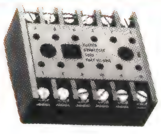
This problem is illustrated with the simple test of a pseudorandom binary sequence generator in Fig. 4. Note that the representative faults chosen for analysis cause the sequences at all nodes of the loop ABCD to differ from the good sequences, so the fault cannot be located by yes/no signature comparison alone.

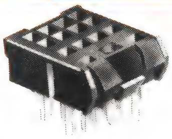
The point is, signature analysis methods prohibit the use of high-resolution diagnostic strategies on feedback-loop circuits—and many circuits designed today, including microcomputers, are of this type. Designing loop-type circuits so that the loops can be opened would be beneficial to any test method, including signature analysis. However, cost, density and reliability requirements may preclude adding the extra parts required to do this.

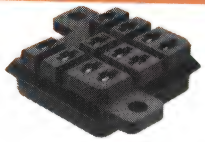
Nevertheless, there are many applications where signature analysis is appropriate and sometimes essential—in data processing or where data bases could become immense without compression. Consider current systems that use pattern generation. They employ very long sequences to achieve high levels of fault excitation. Recording the resulting data, bit-by-bit, would exhaust the order-keeping capability and capacity of even moderate-size computers. In addition, small, low-cost systems often require the user to compare sequence data to recorded values or to the response of a good (physical) circuit. Here, as with pattern generation, data compression makes them work.■■

How useful?	**Circle No.**
Immediate design application	547
Within the next year	548
Not applicable	549

IF YOUR BUSINESS DEPENDS ON THE RIGHT CONNECTIONS, WE'LL MAKE THEM FOR YOU.


Model SD12. For Struthers-Dunn 219 Frame Relay and Proximity Switches.

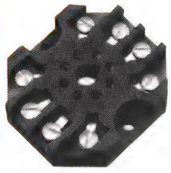

Miniature MR Series. No retaining ring. Pre-wire it.

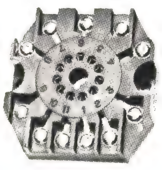

CM Series. Square base. Chassis mount. Quick-connector solder terminals.

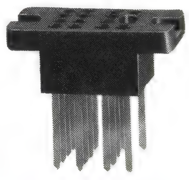
Model QC11 Top wired. Closed back.

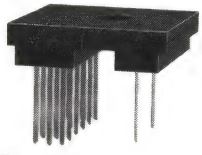
Promptly. That's right, Custom Connector will design and produce any relay socket you need. With more precision and less time than anyone else. Because we've got the years of proven design experience and manufacturing skill that it takes to do it.

We may have already made what you need. If we haven't, just send us your specs. We'll send you our quote on engineering and producing exactly what you're looking for. You can rely on us.


Model RB08. Top wired. Closed back.


Model RB11. Top wired. Closed back.


Miniature MR Series. For automatic wiring equipment.


Telephone Relay Socket Produced for a major elevator manufacturer. Body of Noryl thermoplastic. Contacts of tin-plated Berylium copper.

Custom Connector Corporation

WRITE NOW FOR OUR FREE BROCHURE.
1738 East 30th Street
Cleveland, OH 44114 (216) 241-1679

CIRCLE NUMBER 27

Harris shatters the Op Amp speed barrier:

memo

from purchasing:

Joe—
Here's a monolithic
Op Amp that out-
performs our high
priced hybrids.
Check the unit
price!

12,500.00 +
100. =
125.00 *
860.00 +
100. =
8.60 *

0.5 V /Div.
10 ns /Div.
HA-5190

The first true Op Amp with performance compatible with high-speed Data Acquisition and Display systems.

Harris sets a new benchmark for high-speed amplifiers.

The Harris HA-5190 wideband, fast-settling Op Amps provide the high-speed performance of costly hybrids—with the economy of monolithic bipolar construction.

Result: The industry's highest performing true Op Amps for as little as $8.60 (100-up).

You get the advantages of Harris' unique Dielectric Isolation technology—6.5 MHz full power bandwidth, ±200 V/μs slew rate and settling time of 70 ns (0.1%, 5 V output step). Plus excellent input characteristics of 5 mV offset voltage and 15 $\text{nV}/\sqrt{\text{Hz}}$ input voltage noise at 1 kHz, and the facility of inverting and non-inverting mode operation.

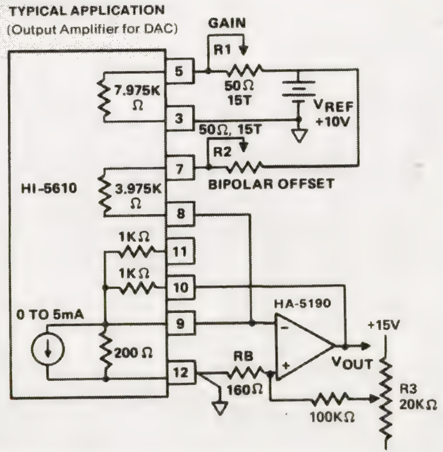
Now you have an economical, true Op Amp to match the performance of high-speed DACs. The natural choice for data acquisition, pulse and wideband video amplifiers, avionic and military equipment, and a variety of graphic displays.

For fast facts, check the specs below . . . then call the Harris Hot Line. Or write:
Harris Semiconductor Products Division, Box 883, Melbourne, Florida 32901.

PERFORMANCE PARAMETERS

INPUT OFFSET VOLTAGE	5	mV
BIAS CURRENT	5	μA
FULL POWER BANDWIDTH	6.5	MHz
RISE TIME	11	ns
SLEW RATE	±200	V/μs
SETTLING TIME		
5 V to 0.1%	70	ns
5 V to 0.01%	100	ns
POWER DISSIPATION	600	mW

TYPICAL APPLICATION
(Output Amplifier for DAC)

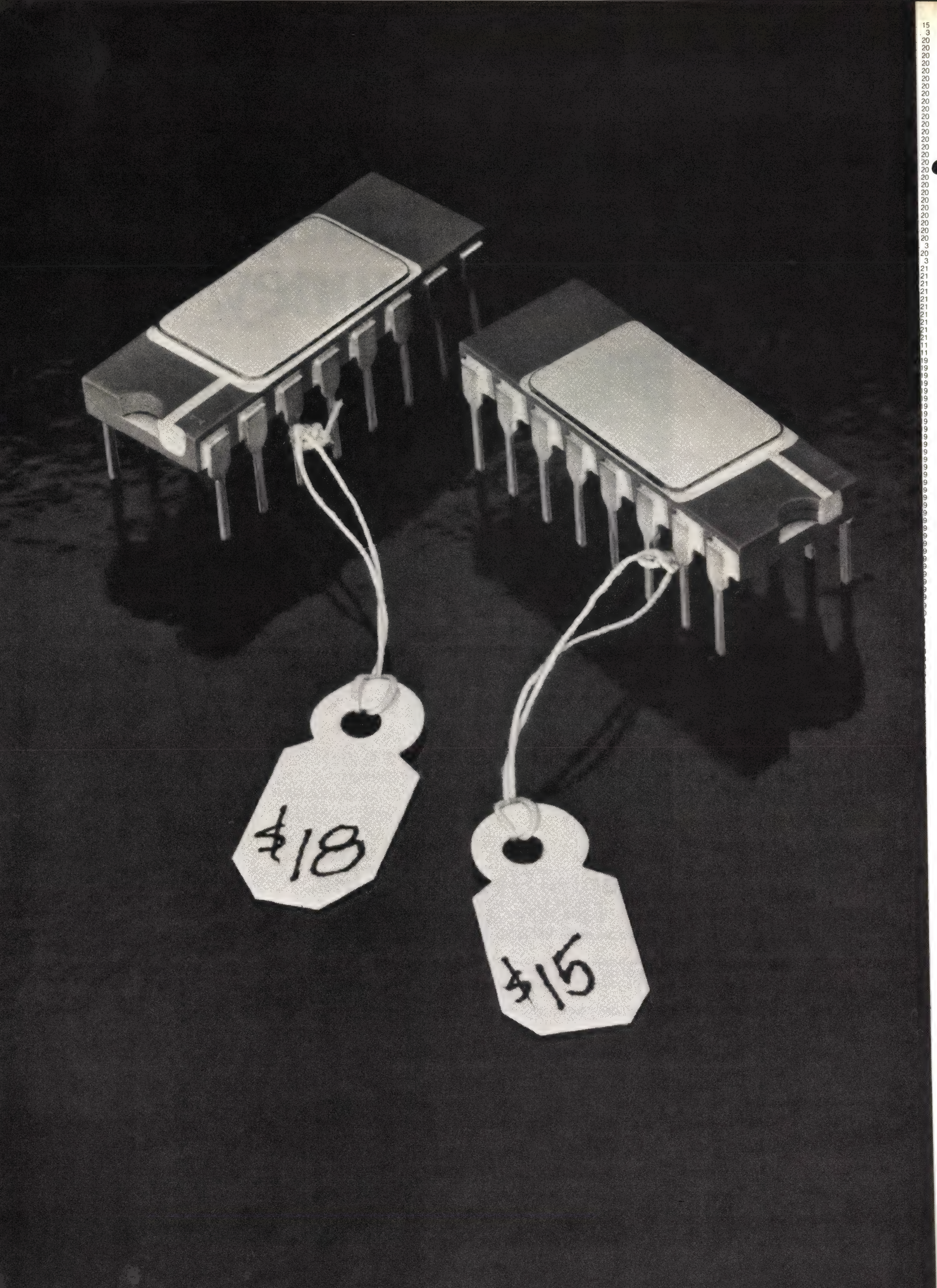


HARRIS HOT LINE!
1-800-528-6050, Ext. 455
Call toll-free (except Hawaii & Alaska) for phone number of your nearby Harris sales office, authorized distributor or expedited literature service.

Harris Technology
. . . Your Competitive Edge

CIRCLE NUMBER 28

HARRIS
SEMICONDUCTOR
PRODUCTS DIVISION
A DIVISION OF HARRIS CORPORATION


$18
$15

There may be no difference.

But, because of cautious test system guard bands, too many high performance memories are downgraded, their potential lost to manufacturers as a revenue source and to users as a factor in new designs.

Now, however, the new J387A Memory Test System from Teradyne lets you set the tightest guard bands ever. Its half-nanosecond accuracy in edge placement gives you higher yields of premium devices. And you can bin with added confidence throughout the performance distribution of a memory design.

The J387A delivers its half-nanosecond accuracy with plenty of speed, too. You get 20 MHz for dynamics, and 40 MHz for statics.

Plus the flexibility of 16 independent timing sets for testing complex devices like the 5-volt, address-multiplexed, page-mode memories.

Couple the accuracy, speed, and flexibility of the J387A with its powerful software and uncommon system reliability. Factor in Teradyne's Automatic Edge Control II, which eliminates manual calibration. And add, for engineering applications, the optional Real-Time Bit Mapping for chip evaluation and characterization down to the bit level.

The result is a superb production, incoming inspection, and engineering memory test system, whose performance and correlation are unrivaled in the industry.

The Teradyne J387A Memory Test System. It gives you A Definite Edge. And that can make all the difference.

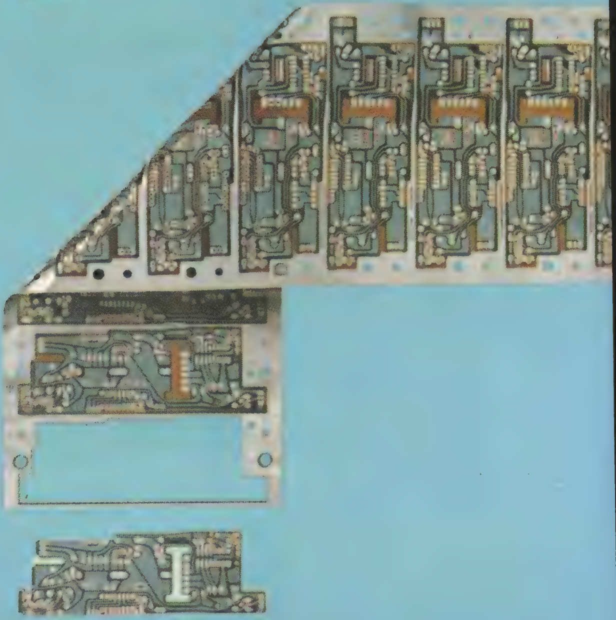
For more information, write: Memory Product Group, Teradyne, Inc., 21255 Califa Street, Woodland Hills, California 91367.

WHAT'S THE DIFFERENCE BETWEEN AN $18 MEMORY AND A $15 MEMORY?

TERADYNE

CIRCLE NUMBER 30

When you go big in flex circuits

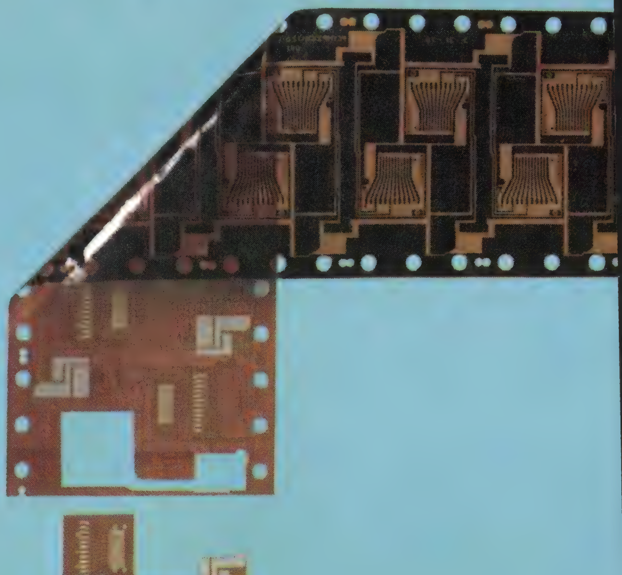


Go right with Rogers.

If your usage of flexible circuits will be high volume, start your new project with a company that can deliver.

Rogers' unique in-house capability to meet demanding requirements for flexible laminates gives you a flying start on truly cost-effective flexible circuitry. Roll-to-roll processing in greatly expanded production facilities further contributes to economy.

Rogers has in-depth engineering support for your program and responds promptly to requests for application engineering assistance. One call to (602) 963-4584 will put you on the way toward uniformly reliable, high-volume flexible circuits.



Circuit Systems Group
Rogers Corporation
Chandler, Arizona 85224
(602) 963-4584

ROGERS

EUROPE: Mektron NV, Gent, Belgium JAPAN: Nippon Mektron, Tokyo

CIRCLE NUMBER 31 **CIRCLE NUMBER 52**

ATE brings speedy, complete testing via signature analysis to LSI-board production

Implementing signature analysis in an automated test system having a bed-of-nails fixture extends the technique from field service of LSI-based products to production testing of both memory and microprocessor boards.

As a result, a memory board can be fully tested at rated speed; a go/no-go test can be conducted in less than one second by monitoring data-bus signatures; and faults can be isolated typically in 5 to 15 seconds to the component level. In addition, SA can be effectively applied at normal operating speeds to test a board equipped with a μP and auxiliary peripheral chips. Typically, a few hundred bytes of firmware or less (depending upon board complexity), in conjunction with the processing capabilities of the microprocessor, can be used to verify normal operating modes—without having to model the internal logic structure of the devices used in the board design.

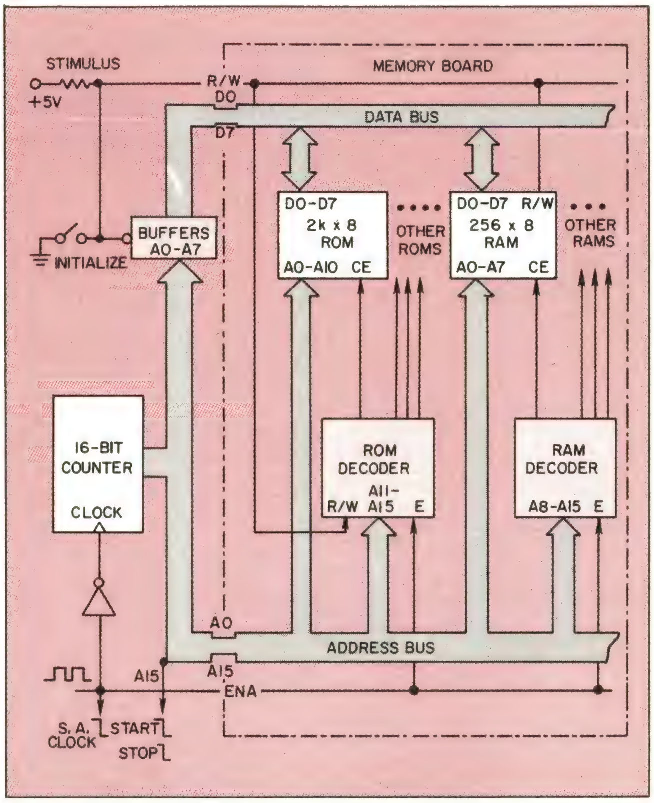
Fig. 1 shows the sort of memory that can be tested with signature analysis. The board consists of both ROMs and RAMs with data and address buses accessible via an edge connector. Each memory element is selected via a chip-enable line, which is decoded from address-bus data. Two control lines are used to direct data flow: Read/Write (R/W) determines the direction of data flow while Enable (ENA) controls the timing (specifying when each device is to drive the data bus). Note that there is no source of internal stimulus for the board, so an external stimulus must be designed into the test fixture.

Stimulate address lines

To test only the ROM portion, the decoder logic is stimulated by the various combinations of address lines A_{11} through A_{15}, while particular ROM addresses are selected by lines A_0 through A_{10}. An externally applied 16-bit counter is a convenient way to stimulate the address lines. The counter itself will be driven via a test system clock, which is also supplied to the clock input of the SA processor. The R/W control line will be controlled via a static, digital drive signal from the test system.

The RAMs can also be exercised by the counter. However, before taking meaningful signatures involving RAM-output data, the RAMs must be initialized. One way to accomplish this is to fill each location in RAM memory with its own address, using the same 16-bit counter as stimulus.

The R/W line is set to the write state, the buffers are enabled and address bits A_0 and A_7 are applied to the data bus. As the counter is cycled through all possible addresses, each writable location is initialized with its particular address. Initialized this way, the



1. Test a memory board carrying ROM with signature analysis by using a 16-bit counter as the stimulus. The SA start and stop signals are derived from the most significant address bit.

John R. Humphrey, Marketing Engineer, and **Kamram Firooz,** R&D Project Manager, Loveland Instrument Div., Hewlett-Packard, Loveland, CO 80537.

RAMs are treated like ROMs for signature tests.

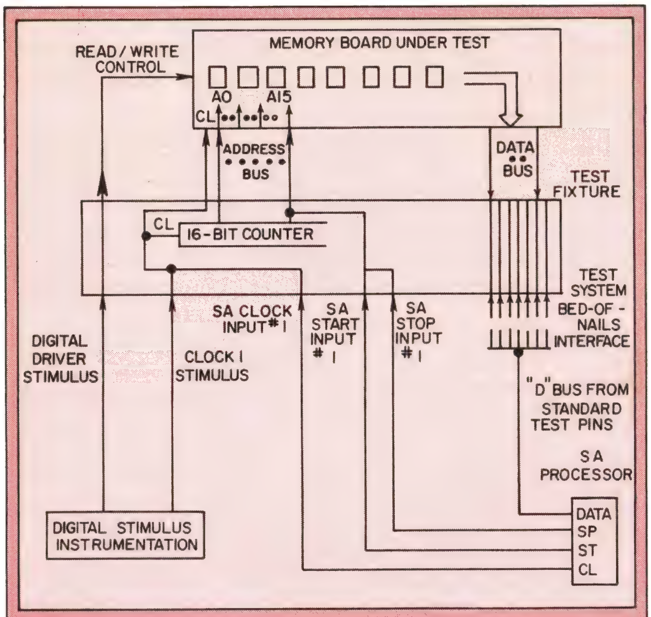
A go/no-go test may be performed on the board by collecting just the eight data-bus signatures. The counter is set up to cycle continuously and the SA measurement window set to monitor all 2^{16} possible states.

The most significant bit of the counter is connected to both the SA start and stop inputs. In less than one second, all decode and data functions may be checked as reflected in the eight data-bus signatures. Fig. 2 shows both the hardware connections and software required to perform this test.

Inside-out isolation

Suppose one or more faulty signatures is measured during the go/no-go test. Faults may be isolated easily using inside-out tracing. First, the 16 address lines driven by the counter are verified over the entire count cycle. If a bad signature is measured, there is a problem with the stimulus circuitry that must be corrected. If the stimulus is verified to be working properly (at 1-MHz clock rate, 16 signatures can be collected in approximately two seconds), the decoder-logic outputs are checked. Should there be a bad decoder signature, back-tracing is performed through the decoder logic until the faulty circuit is found—one with good input signatures but bad output signatures.

Correct signatures at the decoder outputs imply a faulty memory device. Individual memory-device functions may be isolated by varying the source of the start signal, and broadening the address range for successive measurements of the data-bus line where

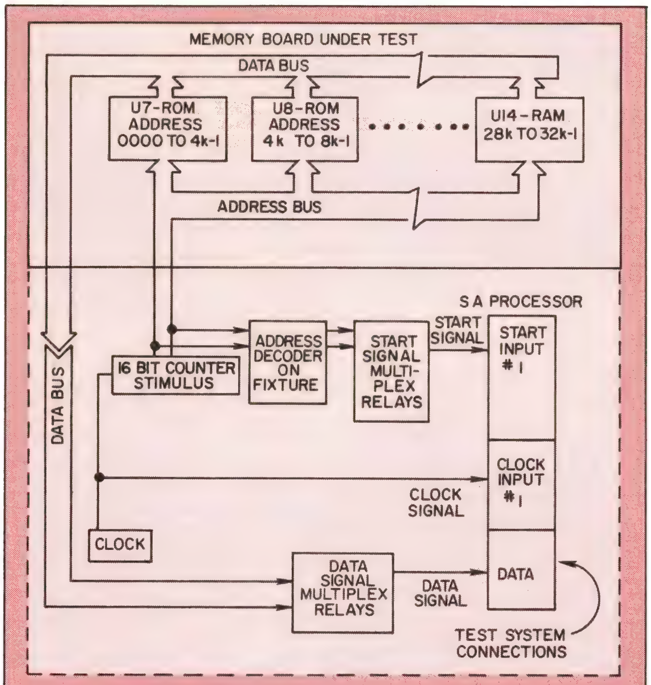


Test Program for Go/No-Go Test

```
Line #   Program Statement                  Description

  1:   "Go/No-Go test for memory board":   Comments for Documentation
  2:   "Tests signatures of 8 data bus":
  3:   "Lines for all possible addresses":
  4:   "RAM's have been initialized":
  5:   rcv ref 1,0.4,2,3.2                 Set SA low, high reference
                                           voltages
  6:   saset 1,"R",1,"F",1,"F"             Set SA to process clock 1
  7:                                       input, rising edge, start 1,
  8:                                       stop 1, falling edges
                                           Initializes SA Processor
  9:   clock 1,1e6,1e7                     Set clock to 1 MHz, free run
 10:   apply "R/W", 1                      Set RAM's to Read
 11:   for I = 1 to 8                      Start of loop for 8 signature
                                           measurements
 12:   mcon N [I]                          Close test node relay speci-
                                           fied by variable N[I]
 13:   sig "", S$[I]                       Measure and check signature
                                           against stored reference
                                           signature S$[I]
 14:   if flg11; gto "DEBUG"               Test pass/fail flag; if fail,
                                           branch to debug subroutine
 15:   next I                              End of measurement loop
 16:   dsp "BOARD PASSED"; gto "START"     Display PASS message
 17:   "DEBUG":                            Start of debug procedure
 18:       .
           .
           .
           .
```

2. A go/no-go test on the memory board can be set up using the eight data-bus signatures to check out the decode and data functions as the memory is cycled through all addresses.



```
     Program Statement           Description

151: for J = 1 to 8          Set up loop to test 8 devices
152: mcon S[J], N[I]         Close start signal relay and data node relay
153: sig "", S$[J], 4096     Take signatures for 4096 clock pulses
154:                         (total memory of current device), compare
155:                         to reference signature S$[J].
156: if flg11; gsb "PRINT    Test flag to see if signature test passed.
     FAULT"
157:                         If not, go to subroutine to print fault
                             message.
158: next J                  End of fault isolation loop
159: gto "RESTART"           After all tests, start new bcard test.
160:
161: "PRINT FAULT":          Entry point of subroutine to orint fault
                             message
162: wrt "PRINTER", "RE-     Write device replacement message.
     PLACE", U$[J]
163: ret                     Return from fault message subroutine.

  -  Data relays set to monitor node where data bus failure occurred
     during go/no-go test encompassing all addresses.
  -  Array S[ ] holds relay data corresponding to address line which in-
     dicates first address of each device.
  -  Array U$[ ] holds designators for each memory element; S$[ ] holds
     good signature data from reference device.
  -  RAM previously initialized.
```

3. Typical software required to isolate one faulty memory device in a group of eight-devices: Variable arrays are used to tabulate the test-node locations and the expected signatures.

the faulty node was found during go/no-go testing. The faulty device is easily determined on the basis of the start signal being used when the failure occurs.

Another possibility is to continue using a start/stop that encompasses the entire range of addresses but selecting the enable pulses of individual memory elements for use as a clock signal. In such a case, only data-bus output for the single device will be monitored by the SA processor.

A third possibility for isolating the faulty memory element is to take signatures on specified clock counts with or without varying the start signal-source. The count parameter may be set to the number of addresses of the device(s) being tested with the start signal derived from the counter bit that represents the first address to be monitored.

Fig. 3 illustrates sample test system software to isolate a faulty memory device in a 32-k memory system consisting of eight 4-k devices. Variable arrays are used to tabulate test node locations and expected signatures, and to set the order of the fault-isolation sequence.

Test a μP board

Fig. 4 shows another new opportunity for signature analysis: a μP board consisting of a Motorola 6800 microprocessor, an on-board clock, power-up support circuitry and various I/O circuitry. On-board memory elements include both ROM and RAM.

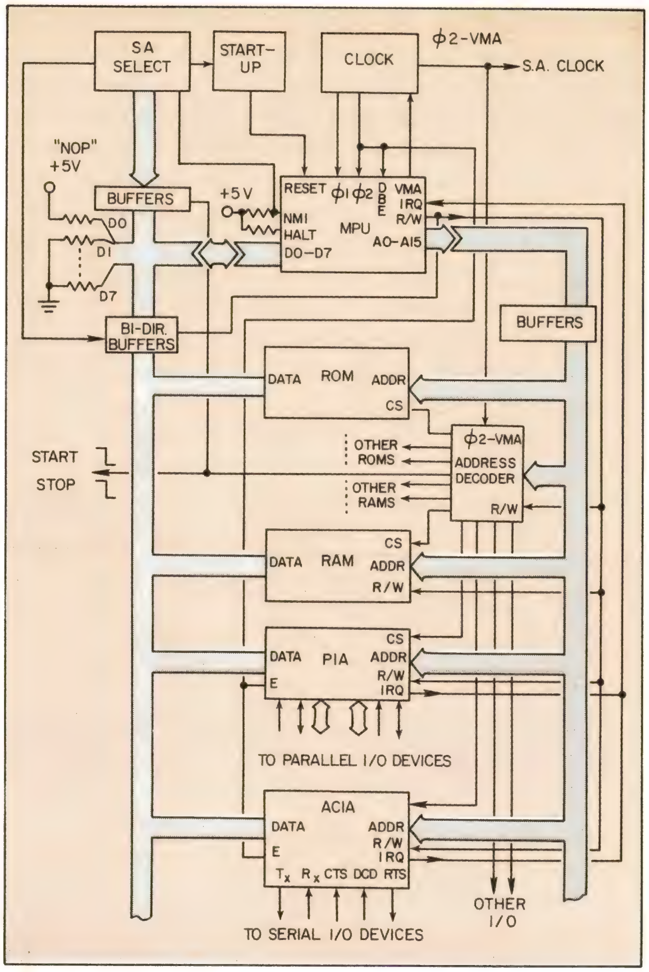
The board uses a 16-bit address bus and an 8-bit data bus. There are buffers on the address-bus lines and bidirectional buffers on the data-bus lines. Control lines employed by the board include Read/Write (R/W), Valid Memory Address (VMA), Data Bus Enable (DBE), and Interrupt Request (IRQ). ROM and RAM elements are driven by combinatorial address decoder logic.

I/O circuits include a peripheral interface adapter (PIA) for parallel I/O devices such as printers, displays and keyboards, and an asynchronous communications interface adapter (ACIA) for serial I/O devices, such as a CRT terminal.

Provisions made within the design requirements for SA testability include:

- Signal lines that may be programmed via switches or ATE-system digital drivers to select vectors that run particular programs in ROM. These are used with a Nonmaskable Interrupt (NMI) to make the μP jump to a firmware test sequence.
- Special firmware in on-board ROM for exercising board elements during a signature measurement.
- A signal line that may be driven by the ATE system to disable the data-bus buffers and break the feedback path to the μP for "free-run" testing.
- Pull-up and pull-down resistors, which may be applied to the μP input to provide a No Operation (NOP) instruction during "free-run" testing.

The test strategy for the board includes, first, in-circuit shorts/opens and discrete-component testing, followed by a functional test sequence that includes both free-run and internal stimulus-driven tests.



4. A microprocessor board built around the 6800 CPU can be tested with signature analysis. Extra hardware and firmware designed into the board will help with fault isolation.

Free-run tests verify that the μP can address memory properly and also verify the ROM contents for SA-stimulus firmware. Internal SA stimulus tests verify the contents of all ROMs, test RAMs, test PIA and test ACIA.

The free-run tests are initiated by electrically disabling the data-bus buffers and applying a NOP instruction to the microprocessor via the pull-up/pull-down resistors. This has the same effect as applying a 16-bit counter to the address bus—the program-counter of the processor will cycle through all possible addresses. SA clock is derived from memory access control functions (phase, clock and valid memory address signals) while start/stop signals are derived from address lines or signals decoded from address functions.

As in the previous example, all addressing functions and all data-storage functions except RAM functions (which must be initialized) may be verified by checking the eight data-bus lines during free run. In this case, however, a different approach illustrates alternative SA test procedures.

First, address functions including the address bus, buffers, and decoder logic are verified by taking signatures on the address bus on both sides of the buffer and at the output nodes of the address decoder logic. Then, the ROM content is verified by selecting start and stop lines from the address bus corresponding to the low and high addresses of the ROMs, and monitoring signatures on the eight data-bus lines.

All this takes place in the free-run mode and requires about 5 s to run at a 1-MHz test rate. Any failures that occur are handled as in the memory-board test. One exception to this might be a test of the board clock in the event of an apparent μP failure, as reflected in a faulty signature on the address bus. The clock into the μP could be checked with amplitude/frequency measurements or by measuring a constant high-condition signature over the free-run window. Such a signature is a function of the number of clock pulses in the measurement window only as previously described.

Given that the ROM containing the SA stimulus tests is "good," then that stimulus may be used for further tests on the board. The firmware for a particular test sequence is executed by controlling interrupt and vector address data to the processor as described previously. The firmware may be written to perform individual tests or to string individual tests together in any desirable sequence, all controlled by vectoring to the appropriate location in the ROM.

SA isolates the fault

The bidirectional buses of LSI boards and of specialized I/O devices can complicate the diagnosis of faults to the component level, when guided-probe and IC-chip tests are used. Although a node may be detected as faulty, the difficulty is to determine which IC, of the five to ten connected to the node, is generating the fault.

Signature Analysis (SA) solves this problem. It is a synchronous process, whereby activity at an electrical node (referenced to a clock signal) is monitored for a particular stimulus over a given time. The analysis that follows the nodal monitoring is based upon data compression: The long, complex pattern of a data stream is reduced into a 16-bit, four-digit "signature." Correct signatures for a particular circuit are determined empirically from tests on a known-good product.

One approach to LSI-board stimulation for SA testing is to "free-run" the board. The circuit runs in a repetitive loop so that only a few of the circuit's logic elements control the process and the maximum number of logic nodes is exercised. In microprocessors, controllers, sequencers and algorithmic machines, free running is often accomplished by opening the data (or instruction) input bus and forcing in an instruction or control that causes a continuous cycling through the entire address or control field. The circuitry that sets up this cycling is referred to as the kernel.

For testing board functions not exercised by free-running, specific test algorithms must be generated to emulate the functional modes of the board in use. For a microprocessor board, the SA stimulus algorithms are written into a portion of on-board or externally connected ROM (as part of the auto-test fixture, for example). Stimulus for the test is thus generated internally, which is easier than trying to stimulate devices surrounding a processor from the I/O ports of the board's edge connector. Furthermore, the data manipulation intrinsic to microprocessors makes the internal generation of algorithms a relatively straightforward task.

The isolation of faults to the component level on circuit boards that employ feedback connections depends upon breaking the feedback paths with hardware and software. This consideration applies both to the test system and to the board under test. For example, the most common loop associated with microprocessor-based boards consists of the processor, address bus, memory elements and data bus. The loop may be broken by providing for a data-bus jumper plug within the design. During production test, the board may be tested before the jumper is installed. After the kernel is tested using a free-run stimulus, test-system relays can be closed to emulate the normal "jumper-in" data-bus connections. Then, additional test cycles may be run in which typical operations of the board are verified.

Feedback could also be disabled electrically by designing the board with buffers to provide three-state operation on selected paths upon command from the test system.

Feedback-loop failures may be analyzed by measuring signatures while the feedback signals are constant ZERO or ONE. Stimulation software can provide a period of constant feedback signals. In some cases, ICs may permit shorting to ground, during the brief period in which signatures are measured, to set feedback paths to ZERO.

Within a bed-of-nails test environment, the capability to select start, stop, and clock signals automatically from anywhere on the board and to perform measurements using start and clock pulse counts can also contribute to effective fault isolation.

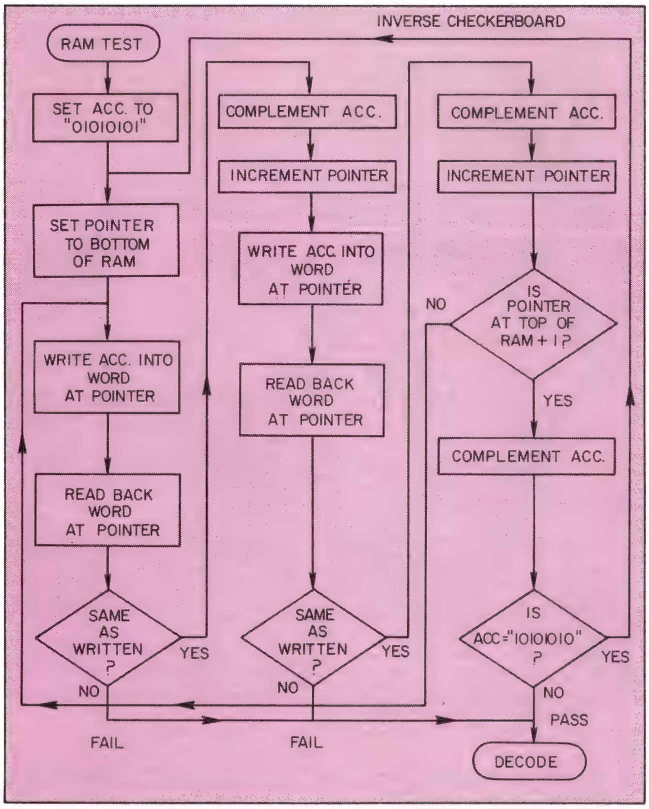
The hardware components of the sample test system typically employed for SA testing are represented by the simplified block diagram in the figure. General system multiplexing is implemented in a row-column matrix, in which any test point may be switched to none, one or any combination of signal buses in a seven-bus multiplexing scheme. These buses may be programmed for both in-circuit and functional testing, as required. For example, the bus structure can be configured to route any one of up to approximately 500 nodes into the SA data-stream processor.

To perform RAM tests, a firmware-based sequence such as that shown in Fig. 5 may be exploited. First, the μP writes alternating ONEs and ZEROs into each word of RAM. Complementary patterns are used in even/odd locations—well-established patterns for testing RAMs for adjacent-bit and adjacent-address shorts. Each word is read back and tested by the μP.

After all addresses are checked, the patterns in each address are complemented and the procedure is repeated. If any cell fails, a flag is set (not explicitly represented in Fig. 5) to register the failure.

At the end of each RAM test, the flag is checked and the firmware takes one of two different paths, depending upon whether a pass or fail condition occurs. If the signature of a constant high condition is monitored during this RAM write/read procedure, a different signature will be registered for each pass/fail condition (since the test signature will reflect the number of clock pulses required to execute the firmware-based procedure).

A table of signatures for all pass/fail conditions may be established within the ATE test program. The RAMs can also be checked by monitoring the data bus during the read/write sequence, which will require eight signature measurements over eight identical stimulation cycles. By monitoring the high-level signal and having the μP perform the data-check function, the same test is executed on the basis of one signature, one stimulation cycle. In the event of a RAM failure, a troubleshooting procedure may be executed as described for the memory-board example to isolate to the faulty device.



5. Testing the RAM on the microprocessor board requires a firmware sequence in which the CPU controls the test program. The program will identify the faulty device.

The PIA provides two 8-bit ports that may be programmed for either input or output functions. The two ports act like latches. Control lines define the data direction and handshaking schemes for passing data. The PIA is effectively stimulated via "PIA" routines in the SA-stimulus ROM. Test-system relays can be used to connect the two I/O ports together at the board-edge connector. Then, one port can be programmed to output while the other is configured as input.

Signatures may be taken directly on data-bus lines to verify proper activity for virtually all possible combinations of the data and control signals. Or, the μP itself can be programmed to perform data-check functions while the high-line signature is monitored, as for the RAM tests. After tests are completed for one combination, the I/O functions can be reversed and the test procedure repeated. In addition, the PIA test firmware can be written to stimulate the device as it is used in the final application.

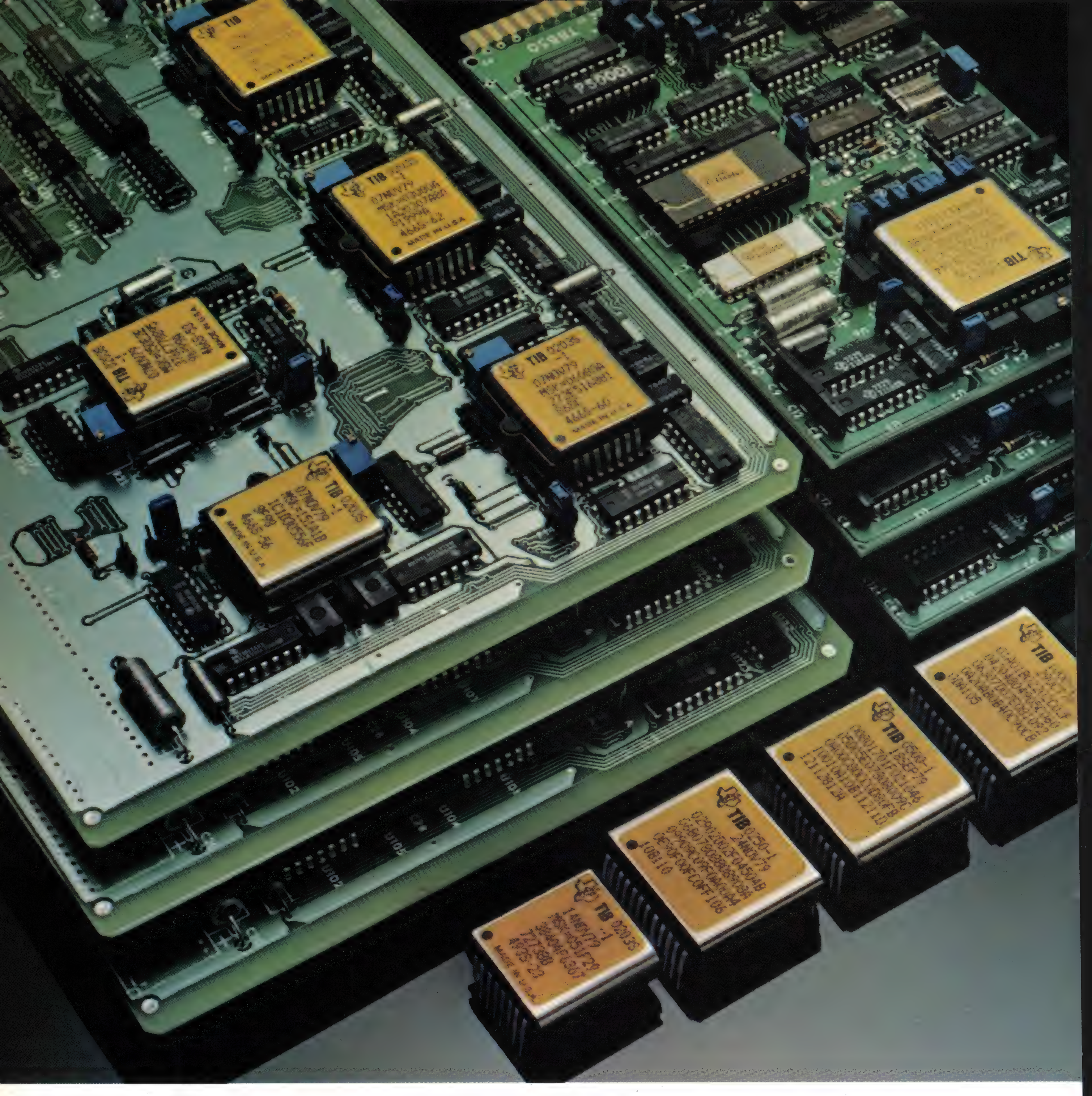
The ACIA is similar to the PIA except that data transfer may be asynchronous with the μP clock, one port is dedicated for the transmit functions and a second port is dedicated to receive functions.

Again, if the two ports are connected together, firmware in the SA ROM may be used to exercise the device. However, the test will have to be synchronous with some reference clock in order to use the normal SA test mode. If this is not possible, then nodal activity may be characterized by taking a high-level signal signature while using the test-node signal as SA clock. The signature will thus verify that the correct number of transitions occurs on the test node.

The ATE test program can be written to perform an efficient go/no-go test on the board by using a free-run test to verify the board kernel and ROMs. Then RAM and peripheral firmware may be executed while monitoring the high-level signature as described to quickly verify correct or incorrect operation.

If faulty signatures occur, some faults will be directly specified by the logic-1 signature. In other cases, tracing algorithms will be required to isolate to the faulty component level.■■

How useful?	**Circle No.**
Immediate design application	**550**
Within the next year	**551**
Not applicable	**552**



The first family of bubble memory systems. Non-volatile. Compact. Easy interface. From Texas Instruments.

TI's family of bubble memory systems offers you the non-volatility of magnetic storage media, plus compactness, silent operation, solid-state reliability, and lower error rates and faster access times than disk and cassette systems.

Because TI bubble memory systems are easily interfaced to microprocessor systems, many designers have already made their choice.

And, they've chosen from the TI family of bubble memory systems.

It's a design decision that makes sense. That's why you'll find TI bubble memory systems improving the performance of intelligent terminals, word processors, industrial process controls, instrumentation and telecommunications equipment, add-on buffer/cache memories — and more.

Because bubble memories are so small and lightweight, they're ideally suited to portable applications such as small computers, data loggers and a variety of educational and home entertainment products.

And the innovations keep on coming. In product breadth. Technology. Production.

New bubble memory systems with storage capacities ranging from 23K to 768K bytes are being supplied. All the custom-designed peripheral and support circuitry for bubble memory systems are available.

New wafer processing techniques, including state-of-the-art planar construction — coupled with TI's innovative two-micron technology — are making newer and better things happen all the time.

TI's eight years of experience in bubble memory design and production have provided keen insights into customer requirements.

Requirements that demanded we deliver. And we have. In fact, TI has delivered more bits of bubble memory than all other suppliers — combined.

Only Texas Instruments can offer you a full family of bubble memory systems. A family built on know-how and experience. A family that reinforces TI's established position as the leader in bubble memory technology — and products.

Systems components

TI's complete family of bubble memory systems is comprised of component devices with capacities from 92K bits to 1 megabit.With access times from 4.0 to 11.2 ms.

These various capacities, along with the necessary support circuits, offer you a wide choice of compact systems for ease of use and design configuration flexibility.

The 1 megabit TIB1000, for example, is electrically and physically interchangeable with family members TIB0500 at 512K and the 256K TIB0250. Both are supported by the same comprehensive line of custom interface circuits.

The planar processing techniques, and new refinements in photolithography allow TIB1000 to offer the highest commercial bit density ever — by a factor of two.

Custom support circuits

All TI bubble memory systems contain a complete set of interface and peripheral circuits — including two custom controllers. One for the 92K devices. One for the megabit family. So, it's not necessary to emulate controller function and you save a design step. Both are available.

These circuits, designed specifically for bubble memories, encompass state-of-the-art bipolar and MOS integrated circuit technologies. This provides high level interface between all of today's popular microprocessors and all of TI's bubble memory products.

The 92K TIB0203 is supported by its own family of custom peripheral circuits. The binary TIB0250, TIB0500 and TIB1000 are all supported by a common set of interface circuits.

TI'S FAMILY OF BUBBLE MEMORY SYSTEMS

PART NUMBER	STORAGE CAPACITY	COMPONENTS	BOARD FORMAT
TM990/210-1	23K Bytes	2 92K-bit	TM990
TM990/210-2	46K Bytes	4 92K-bit	TM990
TM990/210-3	69K Bytes	6 92K-bit	TM990
TBB5005	64K Bytes	1 512K-bit	OEM Board
TBB5010	128K Bytes	1 1024K-bit	OEM Board
TM990/211-1	128K Bytes	1 1024K-bit	TM990
TM990/211-2	256K Bytes	2 1024K-bit	TM990
TM990/211-3	512K Bytes	4 1024K-bit	TM990
TM990/211-4	768K Bytes	6 1024K-bit	TM990

Custom support circuits for all families of devices include: coil drivers, sense amplifiers, function drivers, controllers and function timing generators.

An advanced family of support circuits, coming soon, has been designed for parallel operation as well as error correction.

Bubble memory systems

To provide ease of use and a convenient production board, each new member of TI's bubble memory family is available on a completely assembled, fully tested, compact printed circuit board.

TBB5005 and TBB5010 systems

Non-volatile bubble memory systems assembled on a 4″ x 6″ board with custom controller and all other peripheral devices and using the new family components. Features common to both systems include: up to 128K bytes of memory capacity, interface with TMS9900, 8080 and Z80 microprocessors, access times of 11.2 ms, data transfer rates of 85K bits/sec., system expansion capability and a choice of board connector styles.

TM990/210 system

Here's a non-volatile bubble memory system using the production-proven 92K bit TIB0203 device. Up to 69K bytes assembled on a single board, including a full complement of custom control circuits. Interfaces directly with TMS9900-based microcomputer modules. This system is in stock and available for immediate off-the-shelf delivery from your TI distributor.

TM990/211 system

A non-volatile bubble memory system utilizing the TIB1000 with up to 768K bytes capacity. Bus compatible with TM990/100 microcomputer modules, the TM990/211 system features 11.2 ms access time with data transfer rates of 85K bits/sec. A new module, coming, will be able to be combined with the TM990/211 system to provide a megabyte bubble memory system with on-board error correction, direct memory access, and compatibility with TM990 file management.

And the innovations keep on coming

Texas Instruments is firmly committed to innovative, cost-effective bubble memory technology and product development.

So, for a full line of bubble memory systems — standard or customized to your application — turn to the leader — turn to Texas Instruments for magnetic bubble memory products.

For complete, detailed information and specifications, send for a copy of our new 12-page brochure, CL-473. It's free. Write to Texas Instruments Incorporated, P.O. Box 225012, M/S 308, Dallas, Texas 75265.

Fifty Years of Innovation

TEXAS INSTRUMENTS
INCORPORATED

© 1980 Texas Instruments Incorporated

83729A

DATEL-INTERSIL

SUPER PRINTERS SUPER PRINTERS

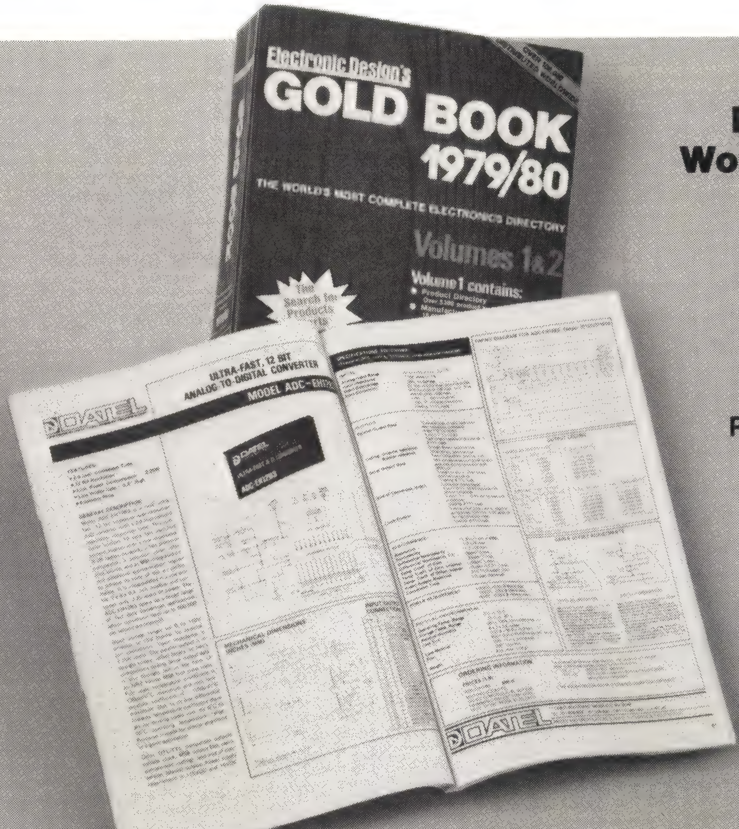
APP-20 ALPHANUMERIC
PANEL PRINTER
•20 COLUMNS/LINE
•NON-MOVING THERMAL PRINTHEAD
•1.5 LINES/SECOND
•POS/NEG TRUE INPUT
•INCLUDES INTERFACE AND POWER SUPPLY
•UNDER 5 POUNDS
•PANEL MOUNTING
•SINGLE CHARPRINT FOR KEYBOARD ECHO
DATEL (617)828-8000

AIP-40

Low cost 40-column benchtop alphanumeric impact printer, parallel or serial input, from **$470**

APP-20 Parallel

Panel mount 20-column alphanumeric thermal printer, 8-bit parallel microprocessor input includes full electronics, **$730.** (+12 VDC version available).


Electronic Design's
GOLD BOOK
1979/80
THE WORLD'S MOST COMPLETE ELECTRONICS DIRECTORY
Volumes 1&2
Volume 1 contains:
ULTRA-FAST, 12 BIT ANALOG-TO-DIGITAL CONVERTER
MODEL ADC-EH12
DATEL

Datel-Intersil and Gold Book. Working Together to Make Your Job Easier!

Together again for the 3rd year — Datel-Intersil and Electronic Design's Gold Book. Volume III of the 1979-80 Edition of Gold Book is the Datel-Intersil Engineering Product Handbook which contains complete specifications, product descriptions and application information.

So don't be delayed on your projects while waiting for product literature to arrive. Check the spec's in Gold Book today.

Electronic Design's, Gold Book the world's most complete electronics directory

DATEL INTERSIL

11 CABOT BOULEVARD, MANSFIELD, MA 02048 / TEL. (617)339-9341 / TWX 710-346-1953 / TLX 951340
Santa Ana, (714)835-2751, (L.A.) (213)933-7256 • Sunnyvale, CA (408)733-2424 • Gaithersburg, MD (301)840-9490
• Houston, (713)781-8886 • Dallas, TX (214)241-0651 OVERSEAS: DATEL (UK) LTD—TEL: ANDOVER (0264)51055
• DATEL SYSTEMS SARL 602-57-11 • DATELEK SYSTEMS GmbH (089)77-60-95 • DATEL KK Tokyo 793-1031

SUPER-PRINTERS

SUPER PRINTERS SUPER PRINTERS

APP-20 Serial

Panel mount 2-wire 20 mA loop serial input 20-column alphanumeric thermal printer. Also includes RS-232-C input and full electronics, **$880.** (+12 VDC version available).

DPP-Q7

Panel mount 7 column numeric/hexadecimal thermal mini-printer, BCD parallel input with full electronics, from **$509.**

MODEL	DESCRIPTION	NO. COLUMNS	SPEED	CHARACTERS	PRINT METHOD	DATA INPUT	POWER SUPPLY	NOTES	PRICE
AIP-40 Type 1 (Parallel)	Low Cost Impact Alphanumeric	40	75 lines/ min.	64 Alpha-numeric (Upper Case)	Impact 5 x 7 dot matrix ink ribbon, 3.9" paper	8-Bit Parallel Synchronous, 40-char. register	115/230 VAC	Double width print control	**$470**
AIP-40 Type 2 (Serial)	"	"	"	"	"	2-wire 20 mA loop or RS-232-C	"	120-char. buffer	From **$690**
DPP-Q7	Panel-mnt. dec/hex thermal with all electronics	7 (6 plus sign)	240 lines/ min.	Numerals or Hexadecimal	Non-impact inkless thermal 7-segment, 1.75" paper	Full Parallel latched BCD, pos/neg true	115/230 VAC built-in	4.4 lb, 105 cu. in. miniature	From **$509**
APP-20 (Parallel)	Panel-mnt. alpha-thermal with all electronics	20	72 lines/ min.	96 alpha-numeric (Full upper and lower case)	Non-impact inkless thermal 5 x 7 dot matrix, 2.3" paper	8-Bit Parallel Asynchronous, 20-char. register, pos/neg true	115/230 VAC switchable, built-in. Optional 12 VDC @ 1A	4.25 lb, 105 cu. in. miniature, selectable inverted (text) printing	**$730**
APP-20 (Serial)	"	"	"	"	"	2-wire 20mA loop, 300VRMS, 100MΩ or RS-232-C Serial, 75 to 9600 baud, 9, 10, 11 bits, 20-char. reg.	"	"	**$880**

CIRCLE NUMBER 33

SUPERTEX ADDS ANOTHER FIRST: BREAKS VMOS POWER FET PRICE BARRIERS!

FIRST : To Break the 10¢ Price Barrier for Chips and 20¢ Price Barrier for Packaged Parts.*

FIRST : To Produce P-channel VMOS Power FETs.

FIRST : To Use High Reliability Silicon-Gate Process in VMOS Power FETs. (Supertex Patent)

FIRST : To Introduce *Standard* Plastic Dual-In-Line, TO-92 and TO-220 Packages.

FIRST : To Introduce High Voltage Arrays for Display and Printer Applications.

FIRST : To Introduce High Voltage Complementary Pairs.

FIRST : To Offer the Most Complete VMOS Line of any Supplier:

Family	Device No.	Drain Current (Amps)	Breakdown Voltage (Volts)	$R_{DS(ON)}$ (Ohms)	gm (Mhos)	Package Options							Availability
						TO-3	TO-39	TO-92	TO-202	TO-220	14-Lead DIP[1]	Dice	
N-Channel	VN01	1–2	40–150	2–8	.15–.25	X	X	X	X	X	X	X	Now
	VN02	2–4	40–220	1–6	0.3–0.5	X	X			X	X	X	Now
	VN03	2–4	300–450	1–3	1.0	X	X			X		X	Now
	VN04	7–10	350–500	0.3–1.0	2.5	X						X	Now
	VN12	4–16	40–220	0.2–1.6	1.5–3.0	X	X			X		X	Now
	VN13	0.5–1.0	40–150	5–20	.06–.10		X	X			X	X	Now
	VN14	.01–.02	40–150	100–400	.02–.03		X	X				X	Now
P-Channel	VP01	0.5–1.0	40–150	4–16	.10–.15	X	X	X	X	X	X	X	Now
	VP02	1–2	40–150	2–8	.15–.30	X	X			X	X	X	Now
	VP03	1–6	200–450	2–6	0.5	X	X			X		X	6/80
	VP04	3–6	200–450	1–2	1.5	X						X	6/80
	VP12	5–10	40–150	0.4–1.6	1.0–1.5	X	X			X		X	Now
	VP13	.25–.50	40–150	10–40	.03–.05		X	X			X	X	Now
	VP14	.005–.010	40–150	200–800	.010–.015		X	X				X	3/80
Complementary	VC01	Each VC01 Contains 2 VN01 and 2 VP01 Devices				Standard Product Available in 14-Lead Ceramic DIP Only[2]							Now
	VC02	Each VC02 Contains 2 VN02 and 2 VP02 Devices				Standard Product Available in 14-Lead Ceramic DIP Only[2]							Now
	VC13	Each VC13 Contains 2 VN13 and 2 VP13 Devices				Standard Product Available in 14-Lead Ceramic DIP Only[2]							Now

*Prices are: 8¢ for VN1304ND in quantities of 10,000 parts, and 19¢ for VN1304N3 in quantities of 250,000 parts.

[1] Standard 14-Lead Plastic DIP containing 4 Devices of Same Device No., Custom Configurations and Ceramic Package Available By Special Order.

[2] 14-Lead Plastic DIP Package and Custom Configurations Available By Special Order. For More Information Consult your Supertex Representative.

SUPERTEX SALES REPRESENTATIVES:

CA.—Orion Sales (213) 240-3151, **CO., UT.**—Comptronics Sales (303) 599-5249, **IL., WI.**—Technology Sales (312) 991-6600, **FL., PR.**—Donato & Associates (305) 733-3450, **ND., SD., MN., WI.**—Smiley-Scott Associates (612) 888-5551, **OH., PA.**—J.C. Hofstetter (216) 725-4477, **NC., SC., GA., AL., MS., TN.**—Macro Marketing (205) 883-9630, **NJ. PA., MD., DE., VA., MI.**—Kirk-Sandell (215) 643-2100, **KS., MO., IA., NE., IL.**—J.O. Schmitz Co. (816) 333-3090, **NE.**—Spectrum Associates (617) 237-3404, **IN.**—SAI Marketing (317) 241-9276, **AK., OR., WA., ID., CA., NV.**—Magna Sales (408) 985-1750 , **NY., NJ., CT.**—Tri-Tek Associates (516) 221-7600, **AZ., NM.**—EDS (602) 277-7407, **TX., OK., AR., LA.**—West & Associates (214) 661-9400, **England**—Dialogue Marketing 01144-6285-26729, **Germany**—Scantec 089 13 40 93, Infratron 040181 75 78, **Japan**—Microtek 03 363 2317, Systems Marketing 03 254 2751, **Korea**—Taeil Trading Co. 22-6741, **Switzerland**—Laser & Electronic Equipment 01 553330, **Denmark**—Advanced Electronic 45 1 24 12 32, **France**—International Semiconductor Corp. 6045275.

SUPERTEX, INC. • 1225 Bordeaux Drive • Sunnyvale, CA 94086 • (408) 744-0100 • TWX910-3399388

CIRCLE NUMBER 34

Component selection weighs heavily in high-frequency switching supplies

This article examines the methods for selecting semiconductor switching components. Part 1 (ELECTRONIC DESIGN, Jan. 18, 1979, p. 74) covered circuit topologies. Subsequent articles will cover passive-component selection and circuit design.

Designing switched-mode converters for high-frequency operation—200 kHz and above—calls for a new look at how circuit components—particularly transistor switches and diodes—perform at those frequencies. The higher the frequency, the more parasitic effects dominate. And the factors ignored at 20 kHz take on significance at 200 kHz.

Nowhere are these factors more important than in the selection of transistor switches and diodes. Like circuit topologies, active components take on a wide range of options, and achieving optimum performance will require many tradeoffs.

Perhaps the best known tradeoff involves the switching transistor technologies—bipolar and MOS. Bipolars are well understood: They are readily available in a variety of speed and power ratings, can handle the highest power requirements, and compared to MOSFETs, are relatively inexpensive. Whether they can work fast enough at 200 kHz and beyond is questionable, however.

MOS transistors, on the other hand, are fast enough to operate at high frequencies, but at present cannot handle the varied voltage and power applications to be served.

Of course, MOS technology is still evolving and when devices are available, it will be able to compete with bipolar in variety and price. For a look at the purely technical tradeoffs, see Table 1.

Since speed is the name of the game in the bipolar-MOS battle, first examine some of the techniques that make bipolars go faster.

Rudolf Severns, Power MOSFETs Applications Manager, Intersil, Inc., 10710 N. Tantau Ave., Cupertino, CA 95014.

Bipolar base drive—key to speed

Fast switching time in bipolar transistors is achieved obviously by selecting fast devices and, not so obviously, by driving them properly.

Often, manufacturers' switching-time test circuits do not drive the transistor on and off hard enough. Therefore, switching times published in data sheets are not always indicative of a device's true capabilities. A gain-bandwidth (f_t) figure is a more reliable indication of high-frequency usefulness. Generally, f_t must

Table 1. MOSFET/bipolar comparisons

MOSFET	Bipolar
1. 10 to 20-ns switching times readily achieved.	1. Transition times of 50 to 200 ns at best with careful base drive design.
2. No storage-time effect.	2. Storage times of 500 to 1500 ns common, reducible to 150 to 300 ns with antisaturation circuits.
3. Very low drive power required.	3. Base-drive requirements relatively high, especially with base overdrive for fast switching.
4. More expensive at present, but should be much cheaper in the future.	4. Lower cost, even for fast ones.
5. Limited selection of power devices.	5. Very wide variety of high-speed and high-power devices available.

be 10 MHz or greater, and the devices should be tested in the actual circuit.

An idealized base-current drive waveform is shown in Fig. 1. At turn-on, the base must see a large, fast-rising current pulse. With the transistor fully on, the turn-on pulse is removed, and sufficient base drive —in proportion to the collector current, if possible—should be provided to keep the device in or near saturation. At turn-off, a large, fast-rising negative pulse is applied to minimize both the storage and turn-off transition times. During the off-time, clamp the transistor's base to the emitter through a low impedance. This minimizes false turn-on resulting from noise and capacitively coupled currents induced by high dv/dt's in other parts of the circuit. These requirements are not especially difficult to achieve, and a variety of circuits are available.[1]

A few methods to properly drive bipolar transistors with a DS0026 clock driver are illustrated in Fig. 2. The 0026 sources and sinks 1 A in under 20 ns, besides providing an excellent interface between the logic and switch driver.

To reduce bipolar storage time, an antisaturation circuit can be designed to prevent the collector voltage from falling below the base voltage. One simple way to do this is by overdriving with a Baker clamp (Fig. 3). While this circuit reduces storage time by four or five times, rise and fall transition times are virtually unaffected.

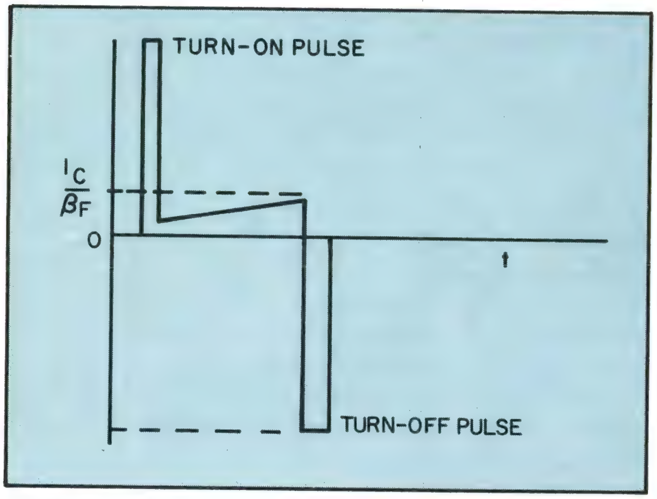
However, bear in mind that there is a limit beyond which overdrive offers no further improvement. While the limit varies from one device to another, the forced beta need not be less than 2 or 3. In fact, excessive overdrive leads to current crowding, which reduces the transistor's second-breakdown energy capability.

Some transistors—high-voltage types especially—display a region of quasi-saturation at turn-on, as shown in Fig. 4. The reason is that the device's active area turns on progressively, not all at once. In transistors built with an interdigitated structure, this effect is less evident. Unfortunately, data sheets are of little help in uncovering quasi-saturation problems, so the only alternative is to test a number of different devices in the actual circuit. This also holds true for locating turn-off quasi-saturation and current-tail problems, which occur in many switching transistors.[2]

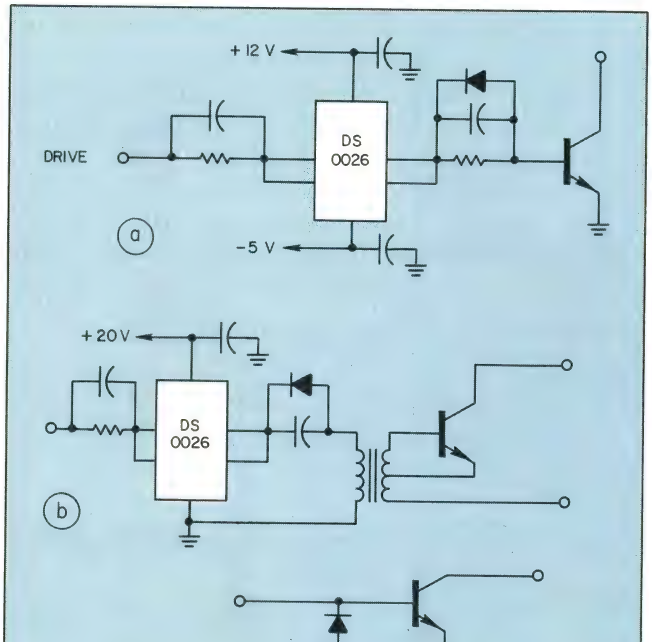
Table 2 lists some common switches and their key switching parameters. One way to overcome the speed drawbacks of bipolars without designing special circuits is to turn to an entirely different switch—the MOS transistor.

Table 2. Typical bipolar performance limits

Part	V_{CEO}	I_C	t_r	t_f	t_s	f_t
2N5330	140 V	20 A	50 ns	30 ns	300 ns	20 MHz
2N6280	140 V	50 A	60 ns	60 ns	400 ns 70 ns clamped	30 MHz
2N6590	450 V	10 A	60 ns	100 ns	400 ns	40 MHz
D62T	500 V	100 A	150 ns	150 ns	800 ns clamped	10 MHz
GSDS 50020	200 V	50 A	100 ns	100 ns	400 ns	?



1. The ideal bipolar base-drive signal turns the device on with a fast rise-time current pulse. Turn-off comes with a similarly fast pulse, but in the negative direction.



2. Drive circuits for bipolar transistors take many different forms depending on the application. A DS0026 clock driver (a and b) makes a good interface element because it handles high current (1 A) and switches quickly (< 20 ns).

MOS gate drive—fewer problems

The gate-current drive waveform for a MOSFET is very similar to that of a bipolar transistor except that during the on-time the current is essentially zero.

A MOSFET gate presents a capacitive load to the driver, and turn-on speed is limited primarily by the driver's resistance and the circuit's parasitic inductance. However, because a MOSFET has an npn transistor inherently built into its structure (Fig. 5), triggering this transistor imposes another special limitation—turn-off dv/dt.

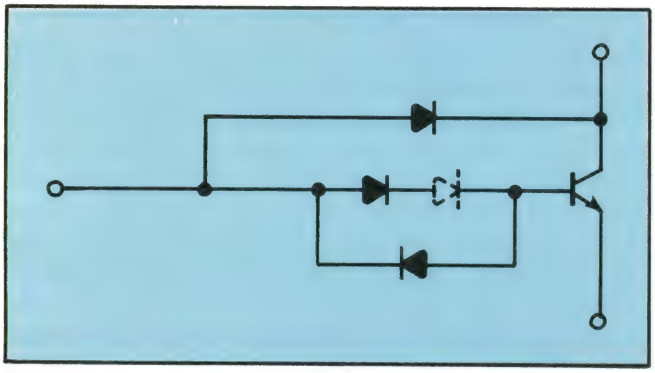
When a MOSFET's drain is rapidly pulled positive, current is injected into the npn's base through capacitor C. If too much current is injected, the npn turns on, possibly destroying the device. The dv/dt limitations of a particular MOSFET depend greatly on geometry, and this varies considerably between devices. And since data sheets do not contain information on dv/dt, designers must contact the manufacturer to learn of the limitations. Currently, most MOSFETs have a dv/dt capability of 10 V/ns or more, which is ample for most switching regulator designs. Fig. 6 shows some of the more common circuits for driving MOSFETs.

When it comes to delivering high power levels, MOSFETs enjoy a clear advantage over bipolars since they are more easily paralleled. Parallel switches must share current equally, not only during the conduction interval but also while switching. As shown in Fig. 7, bipolars (b) require many parameters to be matched for parallel operation while MOSFETs do not (a).

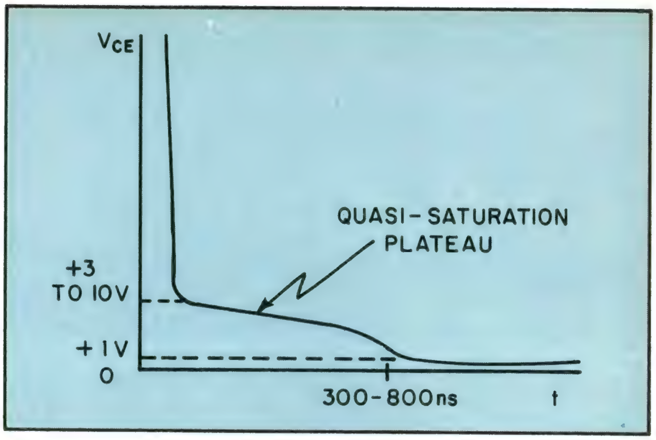
Paralleled MOSFETs should be matched primarily for threshold voltage (V_{th}) to ±10% or closer. The device's positive temperature coefficient then takes care of equalizing the on-state currents. As long as the gate voltages track each other, the devices will share current during turn-on and turn-off.

But even with perfectly matched devices, asymmetrical current sharing can be induced if the circuit's parasitic inductances and resistances are asymmetrical. The effect is either to produce dissimilar gate-drive waveforms or to delay the drain-current rise time. To avoid these problems, use symmetrical board layouts such as ring or start connections. Then verify that the transistors actually share current equally.

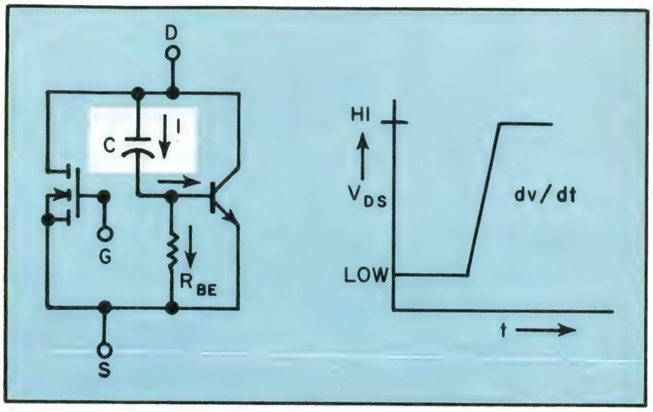
To build high-voltage switching supplies, it is some-



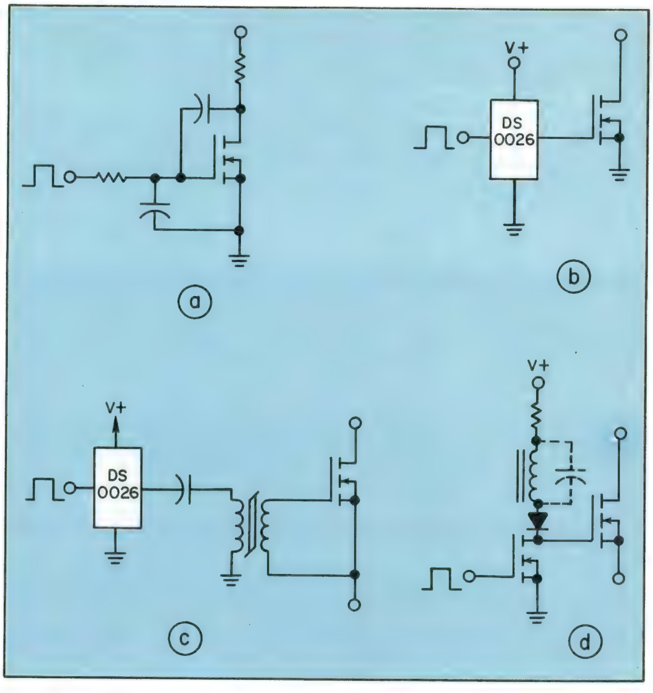
3. Overdriving to reduce storage time speeds up bipolar transistor operation, and one of the simplest overdrive circuits is the Baker clamp.



4. Too much overdrive hinders a bipolar transistor from going into saturation. The plateau, which can last a few hundred nanoseconds, represents the device turning on a little at a time rather than all once.



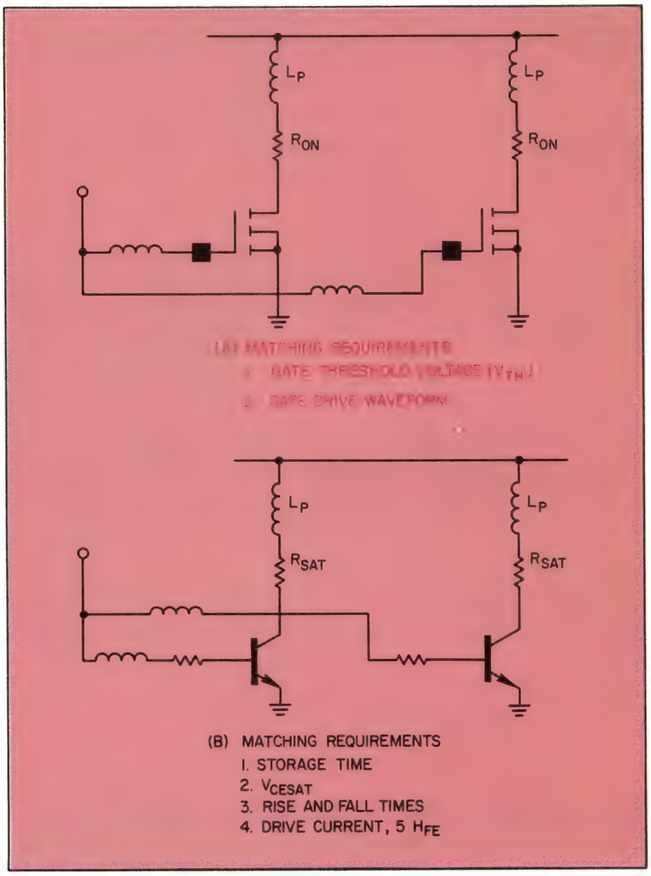
5. Parasitic npn switchback is inherent in the structure of MOSFETs. If too much current flows through capacitor C, the npn turns on, destroying the device.



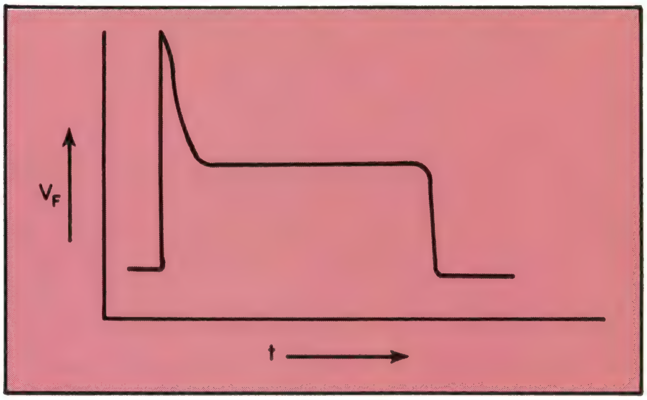
6. Gate-drive circuits for MOSFETs resemble bipolar gate drives (Fig. 2), even in the use of the DS0026 clock driver IC (b and c).

Table 3. Diode performance limits

Manufacturer	Diode type	V_R	I_F	t_{rr}
Unitrode	UES803	150 V	70 A	50 ns
TRW	SVD450-12	450 V	12 A	70 ns
Semtech	3FF500	500 V	1 A	30 ns
TRW	DSR5100	1000 V	4 A	100 ns



7. Paralleling transistors is easier with MOSFETs than with bipolars. The reason is that MOSFETs require only two matched parameters (a), while bipolars require four (b).



8. When a fast current pulse passes through a diode, a voltage spike is generated that can propagate through the system. If not suppressed, the spike will put damaging stress on other components.

times necessary to connect the switches in series. This is all right for MOSFETs if the stray capacitance of the series string is kept uniform, and the gate drives are identical. But the series connection of bipolars at 200 kHz poses difficult dynamic problems, so the technique is not used.

Just as switching speed is crucial to transistor operation at high frequency, the limiting factor in the performance of diodes is speed.

Speed counts in diodes, too

Above 100 kHz, reverse recovery time (t_{rr}) is the limiting diode parameter. For efficient rectification, t_{rr} should be less than 100 ns, but 200-ns devices can be used if the resulting power loss is acceptable.

Because speed is critical, the types of junction diodes that give satisfactory performance in high-speed switching power supplies are limited to gold-doped and ion-implanted devices. For low-voltage, high-current supplies, Schottky-barrier diodes are the preferred devices. Table 3 lists some popular types with their typical characteristics.

Schottky diodes pose a special problem: Even though t_{rr} is very short, the large junction capacitance of these devices creates circuit effects that are indistinguishable from true t_{rr} problems. In addition, Schottkys have dv/dt limitations. To limit dv/dt (Schottkys tolerate about 0.7 V/ns max.), use snubber circuits—they are useful in any case to limit voltage transients. A current-fed topology is the best circuit design to compensate for the capacitive effects.

A major problem can occur if the circuit imposes a fast-rising current through the diodes—the turn-on voltage spike shown in Fig. 8 is generated. The spike is caused by two separate effects, the inductance of the diode package and the finite time required for a diode to go into full conduction. The second effect is called forward recovery time (t_{fr}) and is present to some extent in most diodes. What t_{fr} does is to allow those spikes that appear in the circuit to stress both the transistor switches and other rectifiers. As with bipolar transistors, most data sheets offer no help in identifying the problem, so it is necessary to test several devices to find the minimum t_{fr}.

Paralleling can be attempted with diodes, but in addition to matching the forward voltage characteristics, it is necessary to balance carefully parasitic inductances and resistances. Symmetrical circuit layout is needed as well as symmetrical windings within the power transformer. Multiple transformer windings must have equal resistances which are distributed within the transformer so that equal voltages are induced in each winding.■■

How useful?	Circle No.
Immediate design application	553
Within the next year	554
Not applicable	555

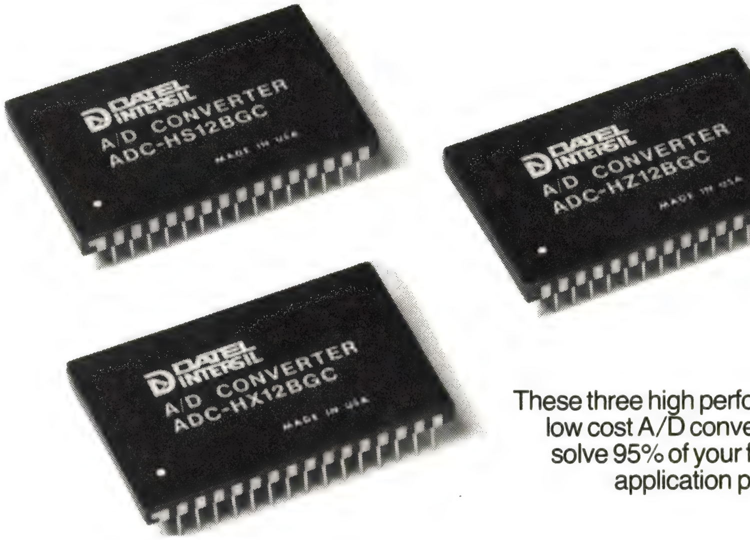
DATEL-INTERSIL

Three 12-Bit A/D Winners.

ADC-HX12BGC
12 Bits, 20 μsec.
internal input buffer

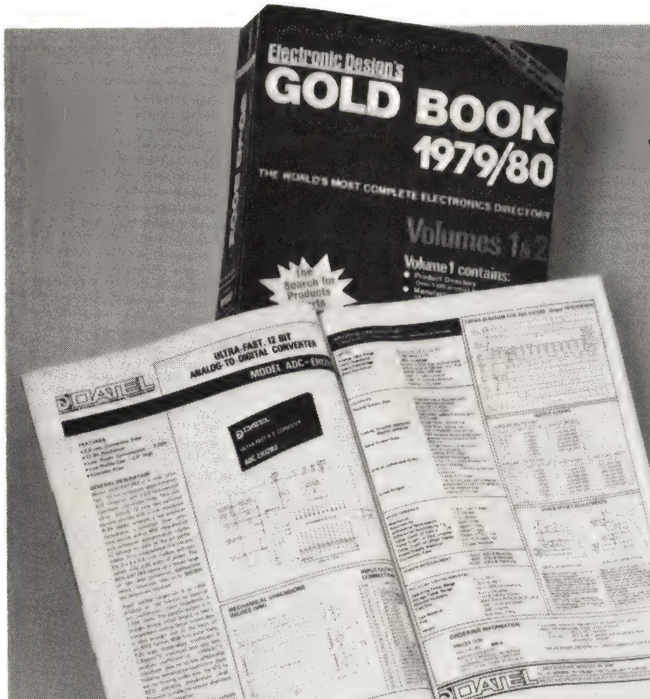
ADC-HZ12BGC
12 Bits, 8 μsec.
internal input buffer

ADC-HS12BGC
12 Bits, 9 μsec.
internal sample-hold



Other Features:
- Hybrid thin-film fabrication
- ½ LSB linearity
- 5 input ranges
- 20 ppm/°C gain tempco
- 32 pin package

These three high performance, low cost A/D converters will solve 95% of your fast 12 bit application problems.


Electronic Design's
GOLD BOOK
1979/80
THE WORLD'S MOST COMPLETE ELECTRONICS DIRECTORY
Volumes 1&2
Volume 1 contains:
DATEL
ULTRA-FAST, 12 BIT ANALOG-TO-DIGITAL CONVERTERS
DATEL

Datel-Intersil and Gold Book. Working Together to Make Your Job Easier!

Together again for the 3rd year — Datel-Intersil and Electronic Designs Gold Book. Volume III of the 1979-80 Edition of Gold Book is the Datel-Intersil Engineering Product Handbook which contains complete specifications, product descriptions and application information.

So don't be delayed on your projects while waiting for product literature to arrive. Check the spec's in Gold Book today.

Electronic Designs, Gold Book the world's most complete electronics directory

DATEL INTERSIL

11 CABOT BOULEVARD, MANSFIELD, MA 02048 / TEL. (617)339-9341 / TWX 710-346-1953 / TLX 951340
Santa Ana, (714)835-2751, (L.A.) (213)933-7256 • Sunnyvale, CA (408)733-2424 • Gaithersburg, MD (301)840-9490
• Houston, (713)781-8886 • Dallas, TX (214)241-0651 OVERSEAS: DATEL (UK) LTD—TEL: ANDOVER (0264)51055
• DATEL SYSTEMS SARL 602-57-11 • DATELEK SYSTEMS GmbH (089)77-60-95 • DATEL KK Tokyo 793-1031

CIRCLE NUMBER 35

Make Fluke your partne

n automated testing.

Buying automatic test equipment is an important investment with long range effects on profitability and efficiency. We recognize the magnitude of this decision and offer you not just a product but a partnership. It's a partnership dedicated to your test needs, based on trust, confidence, and unwavering high-performance.

You're in good company.

When you buy a Fluke system, you join the ranks of companies like IBM, Philips, and Olivetti. In fact, our customers include the top electronics manufacturers throughout the world. Why do these companies choose FAS? Because our systems offer solutions backed by years of experience in solving tough test problems. And because we've reduced their testing costs by one-third.

A close look at testing.

Deciding when to test is as important as how. With an overall goal of high end-product turn-on rates, PC board functional testing is the best approach. It offers comprehensive testing to locate faults across the entire fault spectrum, from production faults to dynamic operational errors.

Deciding how to test comes next. You need to consider a wide range of factors including PC volume, board types, test yield, production yield and anticipated new products. You also need to take a look at the true costs of the system including initial capital expense, programming and diagnostic costs and the kind of service you'll get when every moment of downtime costs thousands.

Take a close look at Fluke Automated Systems. You'll find some surprisingly simple answers to these complex questions.

Making every dollar count: time proven techniques.

We pioneered the concept of reference board testing. Over the years, it has proven to be the fastest, most economical means of board testing, producing higher throughput and superior test confidence.

FAS systems are designed to make test program generation fast and easy to learn. Over 700 automatic stimulus patterns can be selected with the push of a button. For sequential logic, our high level language uses efficient data compression techniques, allowing a user to quickly generate massive stored sequence stimuli. Both techniques can be interleaved "on-the-fly" gaining the advantages of each.

The key to testing is comprehensive test programs. Fluke's test techniques enable exhaustive test sequences to operate at real-time speeds. Extensive test response patterns are data-compressed into a single output signature. Consequently, operation is not limited by disk capacity or access times — problems that plague simulator-based systems.

After test program development, the Automatic Fault Emulator Option verifies comprehensiveness by emulating fault types — from simple "Stuck-at" faults to complex single-bit errors.

Production throughput with a FAS test system is increased by a full spectrum of diagnostic methods. They range from 12 manual aids (including Faultrack® and a built-in logic analyzer for LSI) to a powerful computer diagnostic package called Autotrack®

> 98% Uptime.

The John Fluke Company is founded on the commitment to provide products and services that yield the highest return for your investment dollar. The success of our equipment and the innovative contributions we've made to the industry prove this has not been an empty promise.

Innovative designs are implemented by our manufacturing professionals. Materials are exhaustively screened. Precision components crucial to test performance are 100% tested. In-process inspections are made throughout. The end result: greater than 98% uptime.

Hundreds of experts supporting you.

After a system is delivered, a Fluke Customer Engineer moves in as your consultant to set up your system, give programming assistance and lead hands-on training sessions. He's there to assure that you get maximum utilization of your test system. And he's never more than a phone call away.

For service, you can rely on Fluke Service Engineers working out of 45 service centers around the world. They're dedicated to solving your repair problems in a minimum of time — locally.

Talk to us — we listen.

We solve test problems by listening to you — to what you need, what your problems are. Call us at **(800) 426-0361** or use the handy coupon below. Make Fluke your partner in automated testing.

FLUKE®
AUTOMATED SYSTEMS

IN THE U.S. AND NON-EUROPEAN COUNTRIES:
Fluke Automated Systems
630 Clyde Avenue
Mountain View, CA 94043
(415) 965-0350
TWX 910-379-6573

IN EUROPE:
Fluke (Holland) B.V.
P.O. Box 5053, 5004 EB
Tilburg, The Netherlands
(013) 673 973
Telex: 52237

Tell me more about automated testing.

☐ Send me a literature package.
☐ Let's not mess around — arrange a demo.
☐ I'm a competitor — How'd you make testing so easy anyway?

Name
Title Mail Stop
Company
Address
City State Zip
Telephone ( ) Ext.

For literature circle no. 36

ED1 2/80

Compare our microprocessor design support with anyone's:

	72 hour Burned-in Reliability.		Factory Configured and Tested.		On-Site Installation.		On-Site Local Service.		Extensive Design Workshops.		Total Development Support.	
	Tek's	Theirs	Tek's	Theirs	Tek's	Theirs	Tek's	Theirs	Tek's	Theirs	Tek's	Theirs
8080A	✓		✓		✓		✓		✓		✓	
8085A	✓		✓		✓		✓		✓		✓	
8049	✓		✓		✓		✓		✓		✓	
8039	✓		✓		✓		✓		✓		✓	
8039-6	✓		✓		✓		✓		✓		✓	
8035	✓		✓		✓		✓		✓		✓	
8021	✓		✓		✓		✓		✓		✓	
8048	✓		✓		✓		✓		✓		✓	
6802	✓		✓		✓		✓		✓		✓	
6800	✓		✓		✓		✓		✓		✓	
F8	✓		✓		✓		✓		✓		✓	
3870	✓		✓		✓		✓		✓		✓	
3872	✓		✓		✓		✓		✓		✓	
Z80A	✓		✓		✓		✓		✓		✓	
TMS9900	✓		✓		✓		✓		✓		✓	
SBP9900*	✓		✓		✓		✓		✓		✓	
1802	✓		✓		✓		✓		✓		✓	

*Contact your MDL Sales Specialist for a quotation.

You'll find there's really no comparison.

Tektronix Microprocessor Development Labs offer the broadest range of quality multiple-microprocessor support available today. Tektronix won't lock you into one microprocessor family or vendor. Plus, every Tektronix MDL is backed with over 30 years of design experience. We test our Development Labs thoroughly to ensure maximum performance and reliability. Each one provides complete development capability and the Tektronix commitment that guarantees you'll keep abreast of the fast-paced microprocessor technology.

72 Hour Burned-in Reliability.

Every Microprocessor Development Lab shipped from Tektronix has been burned in at elevated temperatures for 72 hours.

Tektronix microprocessor development labs.

Designed by people on your side of the bench.

FOR TECHNICAL DATA CIRCLE NO. 37

FOR DEMONSTRATION CIRCLE NO. 38

Factory Configured and Tested.

Your system is configured at the factory, then checked and doublechecked against your requirements and our specifications.

On-Site Installation.

Tektronix can send a trained technician to your company to install your Microprocessor Development Lab. You don't have to worry about getting the system running, since it will be set up and ready to work when you are.

Tektronix' full on-site warranty covers any system maintenance or part replacement for three months. Your new MDL is guaranteed to perform at top efficiency from the minute it's installed.

Service Like Nobody's Business.

Tektronix offers localized support in the largest network of MDL service centers throughout the United States and the world. You'll get fast on-site service, without waiting weeks for parts or repairs.

What's more, Tektronix will train your service personnel in system maintenance and troubleshooting. Two-week courses are offered at various service centers.

Week Long Design Workshops.

Tektronix also offers workshops that give your design personnel intensive, practical, results-oriented training. Request the courses that best suit your needs: The Microprocessor Design Workshop, Microprocessor Design Lab Operations Workshop, or the High-Level Language Software Design Workshop.

Your personnel can enroll in regularly scheduled sessions or Tektronix can schedule one or all of these workshops at any field location. Or even at your company.

Full Software and Hardware Support.

Once your MDL has been put in place, you have total development capabilities at your fingertips. Everything essential to software and hardware design is there when you need it—from our Modular Development Language (MDL/μ), macro relocatable assemblers, text editor and debugging software to full in-circuit emulation and real-time prototype analysis.

Send for our free Systems Comparison Chart and compare our Microprocessor Development Lab with anyone's. You'll choose Tektronix because of our unmatched breadth of support, quality and reliability. So don't lock yourself into one microprocessor vendor when in all ways—performance, service and training support—Tektronix is your best choice.

Contact your local Tektronix Sales Office, or write:

Tektronix, Inc.
P.O. Box 1700
Beaverton, OR 97075

In Europe:
Tektronix International, Inc.
1180 AV Amstelveen
Amsterdam
The Netherlands

For immediate action, dial toll-free 1-800-547-1512.
Or in Oregon call collect, (503) 644-9051.

Tektronix
COMMITTED TO EXCELLENCE

Use two drivers with one 7-segment display to get 'custom' nonstandard characters

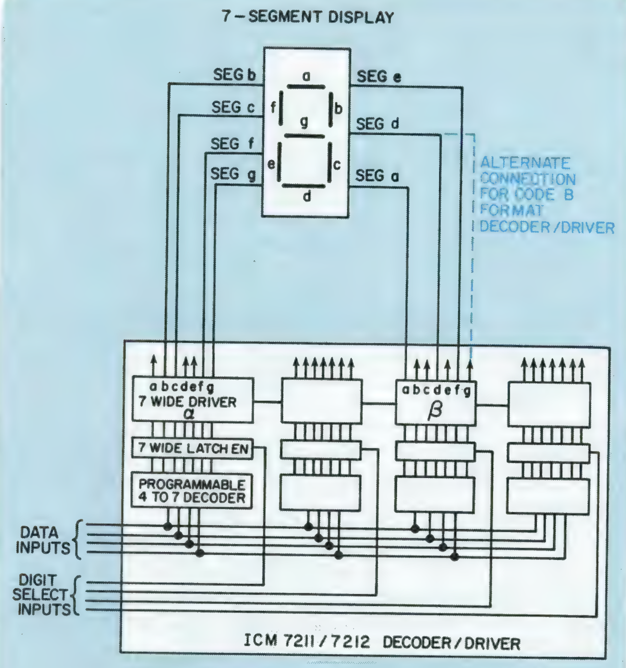
Standard decoder/driver circuits for seven-segment LED and LCD displays generate the usual 0-9 numeric values plus six other characters (A through F for the hexadecimal format; E, H, L, P, dash and blank for the Code B format). When nonstandard characters are needed, they can be obtained easily: Selected segment lines from two decoder/drivers create the desired symbol on one seven-segment display (Fig. 1).

All the new characters are created from selected standard character codes. For example, consider the hexadecimal decoder/driver circuit of Fig. 1, with α programmed for a "2" and β programmed for an "F" (Fig. 2). Driver α has the a, b, g, e and d segment lines energized; but, because only b, c, f and g are connected, just b and g are activated. Driver β has a, f, g and e segment lines energized, but only f, d and a are connected. (Note: Driver output f is connected to display segment e.) Therefore, just e and a are activated. The combination of segment lines that are activated (b, g, e and a) results in a nonstandard character that looks like a question mark.

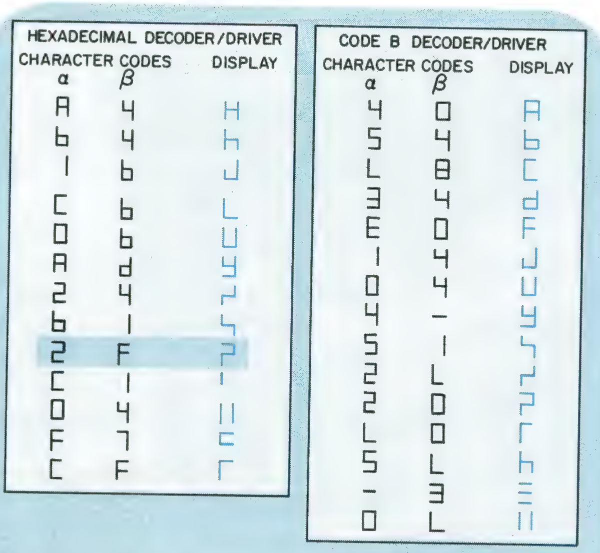
A variety of nonstandard characters can be displayed using the multiple driver approach. However, the connections between the drivers and the display differ slightly, depending on whether the Intersil ICM7211/7212 decoder/driver generates the hexadecimal or the Code B character set.

William H. Beall, Microcomputer Engineering Staff, Intersil, Inc., 10710 N. Tantau Ave., Cupertino, CA 95014.

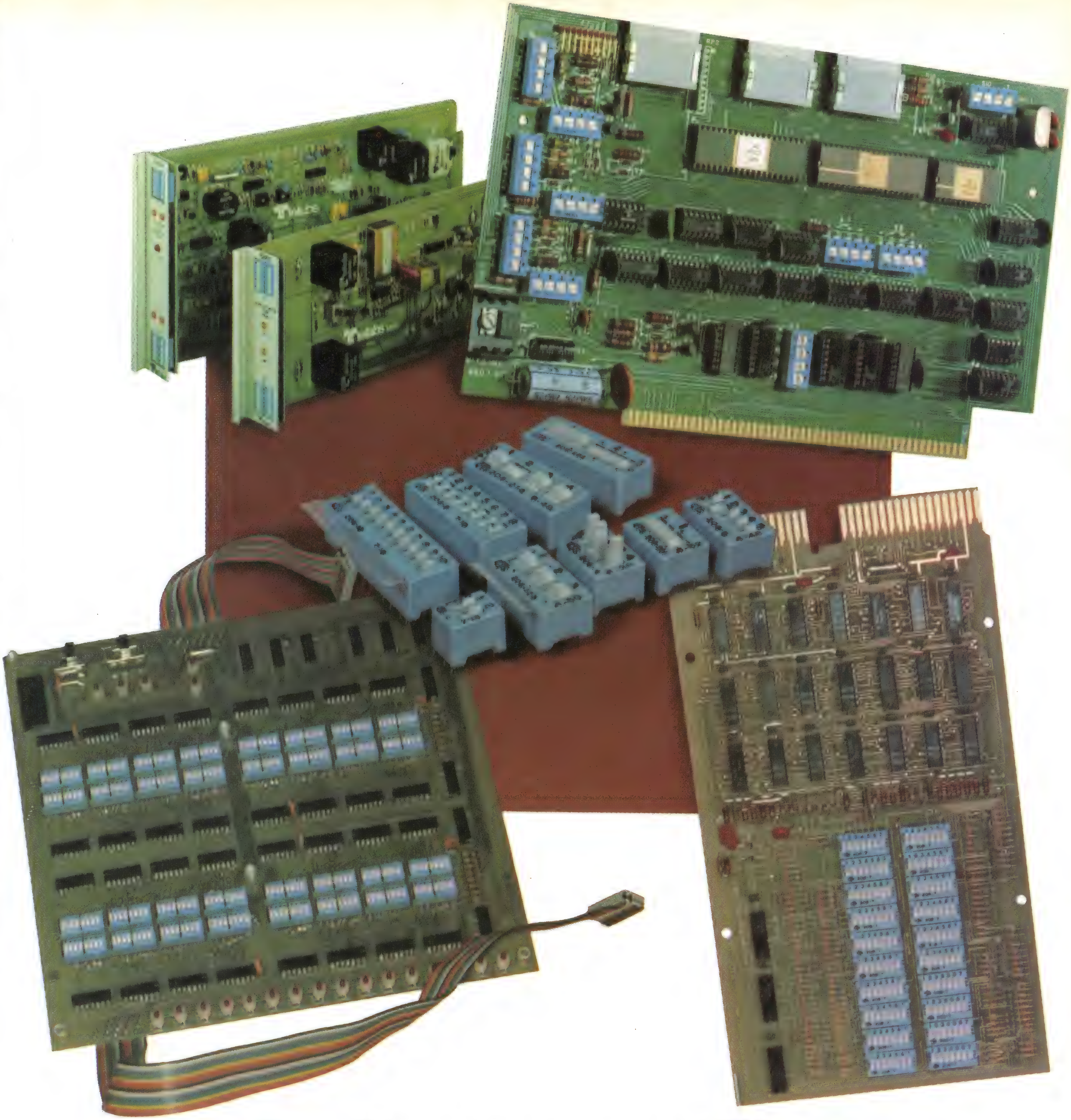
CIRCLE NO. 311



1. Selected output lines from two hexadecimal driver/decoders are connected to one seven-segment display, to present nonstandard characters. Note the alternate connection required by the Code B format.


HEXADECIMAL DECODER/DRIVER
CHARACTER CODES
DISPLAY
α
β
A 4
b 4
1 b
C b
0 b
A d
2 4
b 1
2 F
C 1
0 4
F 7
C F
CODE B DECODER/DRIVER
CHARACTER CODES
DISPLAY
α
β
4 0
5 4
L 8
3 4
E 0
1 4
0 4
4 -
5 1
2 L
2 0
L 0
5 L
- 3
0 L

2. Selected standard-character codes controlling drivers α and β (when connected as in Fig. 1) produce a variety of nonstandard display symbols. For example, consider the hexadecimal decoder/driver with α programmed for a "2" and β programmed for an "F." The resulting display looks much like a question mark.



Quality plus versatility.

CTS Series 206 DIP switches

for communication, data processing, instrumentation and consumer applications ...priced right at your Distributor now!

Choose the configuration you need: SPST, SPDT, DPST, DPDT, 4PST.

You'll get the extra reliability of gold-plated contacts, locked into thermoset base rails. All switches can be supplied with epoxy sealed bases and/or disposable-tape top cover seal to eliminate contact contamination during flow solder and cleaning processes. SPST switches offer choice of low profile or extended actuators with crisp, positive, visible slide action. MIL qualified.

Get the facts! For prices, fast service and complete catalog, contact your CTS Distributor...or CTS KEENE, INC., 3230 Riverside Avenue, Paso Robles, CA 93446. Phone: (805) 238-0350.

CTS CORPORATION
ELKHART, INDIANA

CIRCLE NUMBER 39

Triac senses ac half-cycle polarity; determines direction of motor rotation

A universal motor can be built that operates equally well with forward or reverse rotation. The rotor winding is connected across the output of a full-wave bridge, while the field winding is connected in series with the bridge's ac input. If this circuit arrangement is controlled by a series triac (see Fig.), then triggering the triac on positive-ac half-cycles produces counter-clockwise rotation. Triggering on negative-ac half-cycles produces clockwise rotation.

In this motor control circuit, comparator A1 (1/4 of the LM3900 quad amplifier) produces a synchronizing control signal by monitoring the ac power waveform through a transformer secondary winding. Because A1 operates as a current amplifier, each input leg must have a 220-kΩ current-limiting resistor.

A1's output is low during ac-positive half-cycles and high during ac-negative half-cycles. The resulting 60-Hz square wave is fed to two more LM3900 sections (A2, A3), which are used as logic gates. A2 and A3 are biased to keep their outputs low unless both inputs to A2 are high (about +12 V) or both inputs to A3 are low (near ground potential).

Therefore, the output from A1 ensures synchronization of A2 and A3 to the positive and negative-ac half-cycles, and the external control inputs determine whether A2 or A3 should be turned on. When A2's output goes high, it produces counter-clockwise motor rotation; when A3's output goes high, it produces clockwise motor rotation.

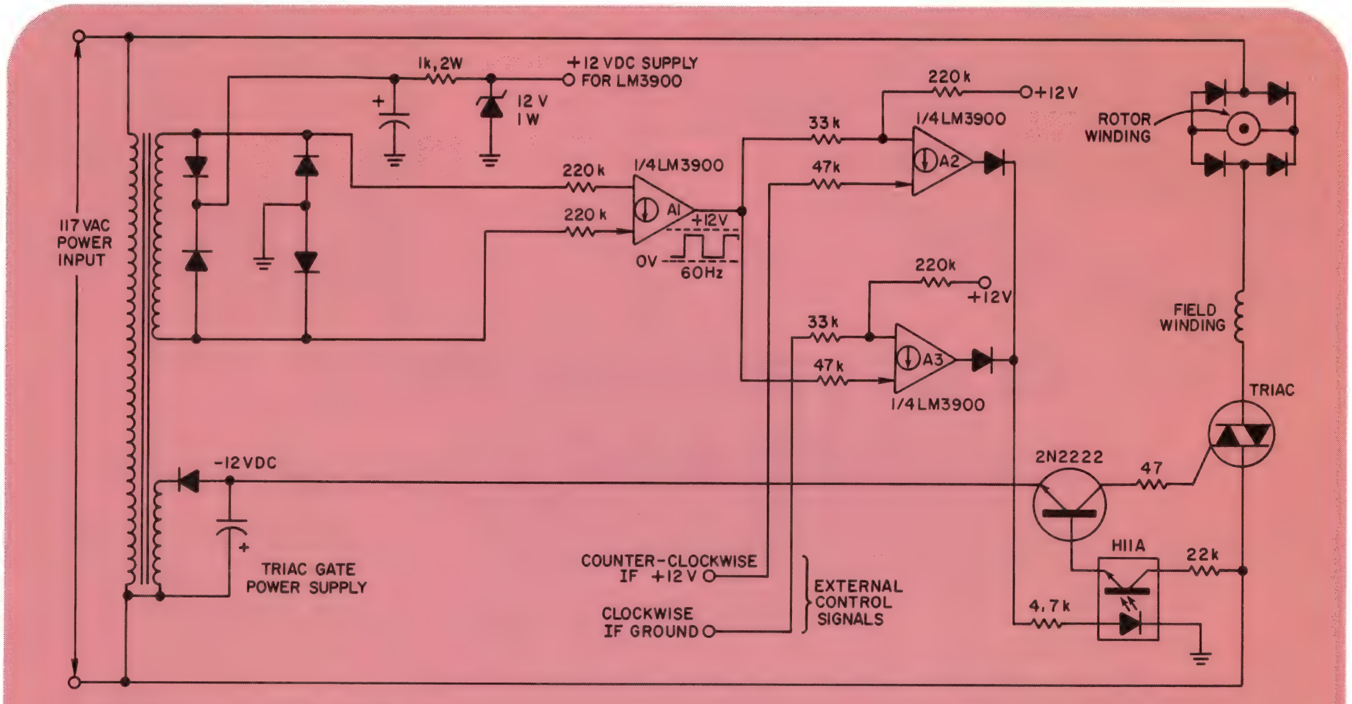
The outputs from A2 and A3 are combined so that either one can independently turn on opto-isolator H11A. A 2N2222 transistor is used to amplify the opto-isolator's output current because of its low current gain (typically 0.4). The gate power supply provides −12 V dc, so that almost any small triac can be used in series with the motor.

References:

General Electric SCR Manual, 1972, p. 184 and p. 299.
National Semiconductor Linear Applications, 1973, p. AN 72-3,4.

David McCracken, Principal Engineer, Thera Institute, P.O. Box 1099, Aptos, CA 95003.

Circle No. 312



Transformer secondary windings and an opto-isolator separate the control, logic and motor synchronizing signals from the power requirements of the triac gate. Clockwise or counter-clockwise motor rotation is determined by external control signals connected to A2 and A3.

TRACE IS THE PLACE

For All Your Printed Circuit Board Test Equipment Needs

Trace Instruments is the *only* manufacturing company that can give you…

Automatic Continuity Testing…
bare board, wired backplane, cable harnesses

Automatic Static Production Test…
loaded board, wired backplane with components

Automatic Dynamic Production Test…
loaded board functional test, complex logic combinations

Our total capacity company gives you customized test fixturing plus interchangeable test heads for easy maintenance and servicing. And spare parts kits, on-site training and development.

TRACE IS THE PLACE FOR…

Furnishing tooling services and tooling kits

Providing program development for determining your testing needs

Maintaining major service and repair centers on the East and West coast

GET THE COMPLETE PICTURE

TRACE IS *YOUR* PLACE FOR…

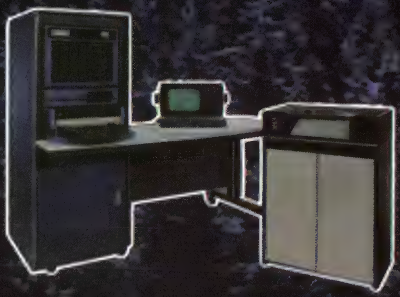
High Quality Production and Testing
With Field Proven Reliability

TRACE MODEL TA-4
Bare P.C. Boards
Cable Harnesses
Wired Backplanes

TRACE MODEL TA-5
Loaded P.C. Boards
Wired Backplanes
with Components

Pneumatic or Vacuum Systems
Automatic Self-Programming
Floppy Disk Mass Program Storage
User Language Translation

TRACE MODEL TL-8
Loaded Board Functional Testing
Tests Complex Logic Combinations
IEEE-Compatible Analog Subsystem
Speedy Pass/Fail Results
Dynamic Guided Fault Diagnostics
Interactive Test Program
Portable Packaging



TRACE
INSTRUMENTS

9030 Eton Ave., Canoga Park, CA 91304 • Phone (213) 341-5593 • TWX (910) 494-5989 Methode Electronics, Inc.

CIRCLE NUMBER 40

TTL-compatible frequency doubler rejects harmonics without tuned circuits

Two retriggerable, monostable one-shots (SN54123s) and one NOR gate (SN54128) plus a few discrete components can be configured as a frequency doubler that accepts a 5-MHz, TTL-compatible, symmetrical square wave and delivers a similar waveform at 10 MHz into a 50-Ω load (see Fig.). Also, harmonic and subharmonic rejection is 40 dB without tuned circuits over a 1-dB bandwidth of ±20%.

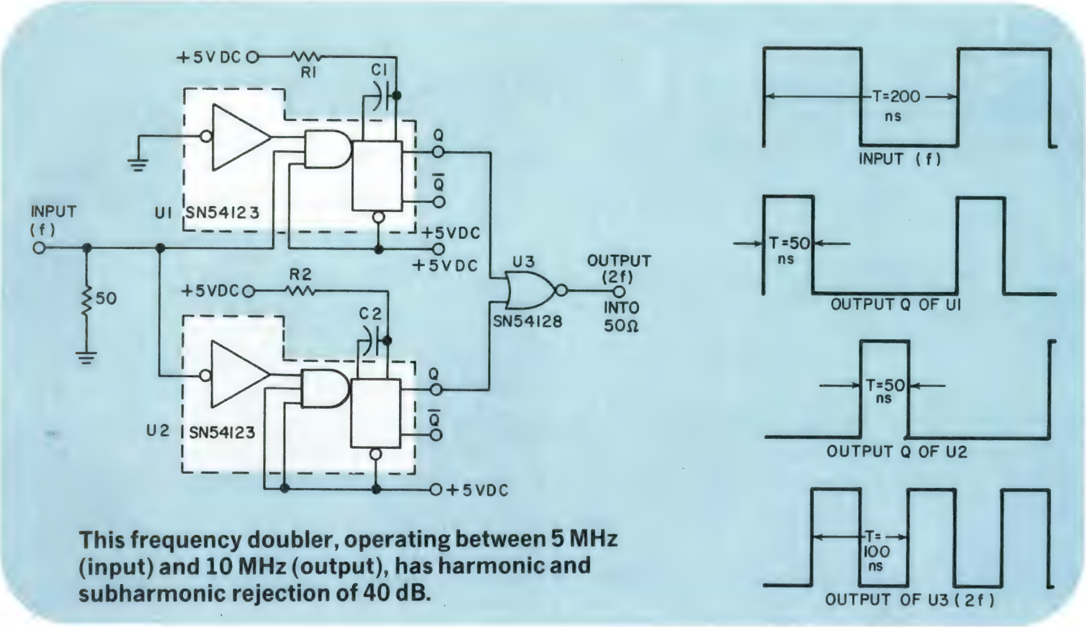
The key circuit elements are the one-shots, U_1 and U_2. Their output pulses are programmed by selecting external resistances R_1 and R_2 and external capacitances C_1 and C_2. These components are selected such that the duration of the output pulse from each one-shot is one-fourth the input waveform period. With the input signal at 5 MHz, period $T = 1/f = 1/5 \times 10^6$, or 200 ns. The pulse widths at the outputs of the one-shots (Q and $\overline{Q}$) are 200 ns/4 or 50 ns.

One-shot U_1 is triggered on the leading edge of the input waveform, and U_2 on the trailing edge of the input waveform. The U_1 and U_2 Q outputs are then applied to the NOR gate (U_3), thus producing a square wave at U_3's output at twice the frequency of the input to U_1 and U_2.

Other important characteristics of this circuit include inherent frequency stability (no parametric oscillations of the type present in transistor or step-recovery diode multipliers) and an output that stays leveled with a 6-dB variation in the input signal. Note that the frequency of operation may be extended by employing ECL circuit components.

Ralph W. Carfi and John T. Bartholomew, Design Engineers, Solid State Equipment Engineering, General Electric Co., Court St., Syracuse, NY 13201.

CIRCLE NO. 313



This frequency doubler, operating between 5 MHz (input) and 10 MHz (output), has harmonic and subharmonic rejection of 40 dB.

IFD Winner for October 11, 1979

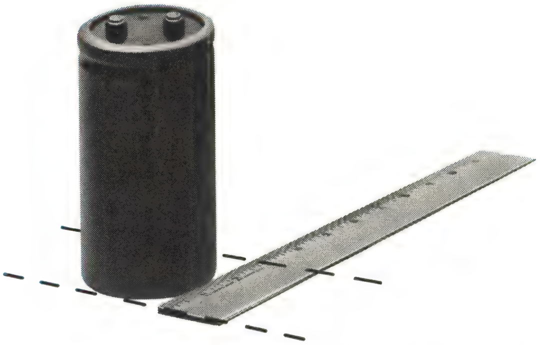
Paul Brokaw, Division Fellow, Analog Devices Semiconductor 829 Woburn St., Wilmington, MA 01887. His idea "Simplified Voltage-splitting Regulator Neatly Divides Single Power Source" has been voted the Most Valuable of Issue Award.

Vote for the Best Idea in this issue by circling the number for your selection on the Reader Service Card at the back of this issue.

SEND US YOUR IDEAS FOR DESIGN. You may win a grand total of $1050. Here's how. Submit your IFD describing a new and important circuit or design technique, the clever use of a new component or test equipment, packaging tips, cost-saving ideas to our Ideas for Design editor. Ideas can only be considered for publication if they are submitted exclusively to ELECTRONIC DESIGN. You will receive $20 for each published idea, $30 more if it is voted best of issue by our readers. The best-of-issue winners become eligible for the Idea of the Year award of $1000.

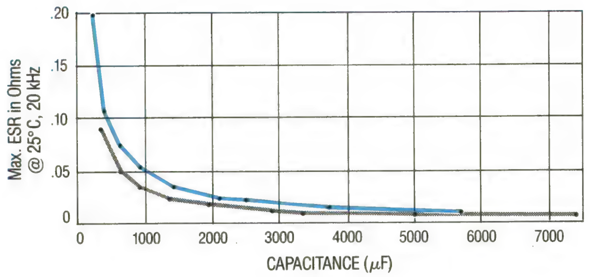
ELECTRONIC DESIGN cannot assume responsibility for circuits shown nor represent freedom from patent infringement.

HIGH CAPACITANCE PER CASE SIZE



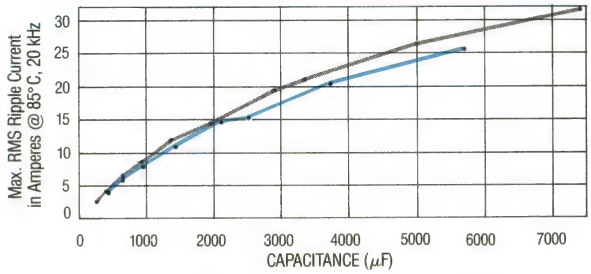
Values as high as 7,400 μF @ 200 VDC in a 3″ x 5.625″ case.

LOW ESR



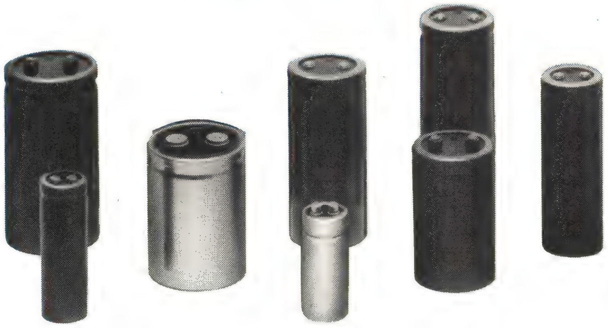
Curve plotted in gray represents capacitors rated at 200 VDC.
Curve plotted in blue represents capacitors rated at 250 VDC.

HIGH RIPPLE CURRENT CAPABILITY



Curve plotted in gray shows ripple current capability for capacitors rated at 200 VDC while curve plotted in blue shows ripple current limits for capacitors rated at 250 VDC.

A RATING TO MEET YOUR NEEDS



Sprague Type 623D Extralytic® Input Filter Capacitors are available in 20 standard ratings ranging from 260 μF to 7400 μF.

New Sprague Type 623D Input Filter Capacitors for switched-mode power supplies

Sprague's new Type 623D Extralytic® Capacitors have been expressly designed to fit both tight space and tight budget requirements . . . *plus* provide superior performance in off-line switching-type applications.

A few of the prime advantages of these new capacitors are highlighted above. Most important, though, is the fact that you can select from standard ratings to zero-in on your power supply requirements without paying for costly specials that necessitate slower deliveries.

For detailed technical data, write for Engineering Bulletin 3461 to: Technical Literature Service, Sprague Electric Company, 347 Marshall St., North Adams, Mass. 01247.

4SE-9115

SPRAGUE®
THE MARK OF RELIABILITY

THE BROAD-LINE PRODUCER OF ELECTRONIC PARTS

a subsidiary of **GK Technologies** Incorporated

CIRCLE NUMBER 41

When you buy automatic test equipment, consider all the costs that affect your bottom line . . .

Look beyond the initial capital investment when buying functional ATE . . . There are major ongoing costs that must be examined. The IE System 390 keeps these costs down. Consider these features.

- Test Program Preparation—MICROSIM time domain logic simulator, MCM-user-oriented language for LSI, VLSI modeling, ATLAS high level language
- Program debugging—accurate simulation, fault trace, interactive editor, on-line compiler
- Maximum fault detection—6 MHz digital test rates, 8 independent programmable clocks for complex timing, programmable logic voltage levels
- Inexpensive test fixturing—system flexibility precludes need for electronics in fixtures
- High production throughput—ample core memory minimizes disc accesses, fast digital probe analyses data on-the-fly
- Low operator skill—user-oriented for production
- Non-obsolescence—system is field upgradeable
- Data logging—permits test result analysis and report generation

These are just a few of the cost saving features you should know more about. Call or write I.E. or its representatives.

Instrumentation
Engineering

While others are talking, we're doing it.

Executive Offices and Plant
769 Susquehanna Ave.
Franklin Lakes, NJ 07417
201-891-9300
TELEX 130-352

West Coast Office
1442 Irvine Blvd., Suite 127
Tustin, CA 92680
714-544-7750

International Sales Representatives

Vanwell Data Systems
11 Kingsmead Square
Bath Avon, England
Tel. (0225) 63213
TELEX 21879

SRA Svenska Radio AB
Torshamnsgatan 21-23 Kista
Fack-163 00 Spanga-
Stockholm, Sweden
Tel. 46 8 752 1000
TELEX 13 545 SRA S

Tekelec Airtronic
Site des Bruyeres
Rue Carle Vernet 92310
Sevres, France
Tel. (1)027-75-35
TELEX 204552F

Ando Electric Co., Ltd.
19-7, Kamata 4-Chome
Ota-Ku, Tokyo, 144 Japan
Phone: (03) 733-1151
TELEX 246-6425
Cable Address Andelec Tokyo

CIRCLE NUMBER 42

Kevlar stretching gives fiber-optic cables more strength at reduced size

Brand-Rex Co., Willimantic, CT 06226. George Graeber (203) 423-7771. P&A: See text.

A special patented process for stretching and bonding Kevlar reinforcement members adds strength to a new line of ruggedized fiber-optic cables without increasing the outside diameter. The new line includes seven cable types, each with a choice of nine fiber types, all specially treated to ensure high tensile and flex strength with optimum flexibility and dimensions.

Fiber-reinforcement members made of DuPont Kevlar are stretched and sandwiched between polyester sheets, which in turn form a protective coating around the fibers. This prestretching increases the tensile strength of the Kevlar to at least 100,000 psi while reducing the outside diameter to 20% of the OD of similarly reinforced fibers.

The seven-types of Brand-Rex cable using the special reinforcement process are described as single-fiber loose-tube, single-fiber tight-tube, two-fiber loose-tube, two-fiber tight-tube, three-fiber loose-tube, three fiber tight-tube, and special six-fiber cable with an interlock coating. Optical fibers, for each cable type, are surrounded by Kevlar-strength members and covered by a PVC jacket (though other jacketing materials can be specially ordered). Regardless of the cable type, each fiber is individually protected.

Stephan Ohr,
Components Editor

The single-fiber loose-tube cable has a cable outside diameter of 3.94 mm (0.155 in.) with a nominal fiber outside diameter of 2.54 mm (0.100 in.). The single-fiber tight-tube cable, on the other hand, has a much lower profile, with an outside cable diameter of 2.54 mm.

The loose-tube duplex has a cable thickness and width of 8.88 mm × 4.95 mm (0.350 in. × 0.195 in.) with a 2.54-mm-OD fiber. The tight-tube two-fiber cable is 6.58 mm × 3.54 mm (0.259 in. × 0.140 in.). The three-fiber cables and other multifiber cables are correspondingly larger.

Compared to the best grades of CATV coax, Brand-Rex fiber-optic cables are smaller and lighter, with wider bandwidth and excellent cross-talk immunity. Signal attenuation for a 75-Ω CATV cable with a 12.19-mm OD, for example, will be up to 100 dB/km at 500 MHz. A 2.5-mm OD fiber-optic cable, in contrast, will lose less than 10 dB/km through-out the entire frequency spectrum.

Brand-Rex cables, in addition, are available with a variety of fiber types ranging from low-loss telecommunications-grade fibers to low-cost plastic-clad silica. The fiber types include graded-index with 55 and 62-μm cores (125-μm cladding diameters), which are intended for high data transmission rates up to 400 MHz.

Other fiber types include step-index (PCS) with 200, 300 and 400-μm core diameters. These are aimed at general-purpose data transmission up to 25 MHz. Cable attenuation is in the vicinity of 7 to 10 dB per kilometer with each fiber type. All nine fiber types are listed in the table below.

In addition to the Kevlar-strength members, fiber jackets can be specified with Acrylate, nylon, Tefzel and PVC protective coatings. In addition to other protective coatings, special low-attenuation high-bandwidth fibers can be specified.

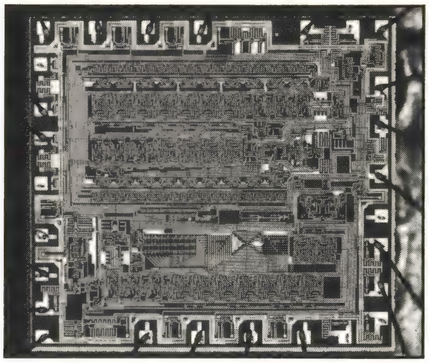
The prices for most cable types will vary from $0.25 to $2.00 per foot depending on the quantity and configuration. for regular orders, all cable tapes will take up to 12 weeks to deliver.

CIRCLE NO. 301

FIBER OPTIC SELECTION GUIDE

FIBER TYPE	PROFILE	DIAMETER CURE	DIAMETER CLADDING	DIAMETER COATING	ATTENUATION dB/km	N.A. (SEE NOTE)	BANDWIDTH -3dB OPTICAL	FIBER STRENGTH
I	Graded	55μm (0.0022")	125μm (0.005")	1000μm (0.040")	<8 @ 0.82μm	0.25	200 MHz	6.9 x 10^8 Nt/m^2 (100,000 PSI)
II	Graded	62μm (0.0024")	125μm (0.005")	137μm (0.0056")	<7 @ 0.82μm	0.21	400 MHz	1.7 x 10^8 Nt/m^2 (25,000 PSI)
III	Graded	62μm (0.0024")	125μm (0.005")	1000μm (0.040")	<7 @ 0.82μm	0.21	400 MHz	6.9 x 10^8 Nt/m^2 (100,000 PSI)
IV	Graded (Modified)	100μm (0.004")	140μm (0.0056")	1000μm (0.040")	<8 @ 0.82μm	0.30	20 MHz	6.9 x 10^8 Nt/m^2 (100,000 PSI)
V	Step (PCS)	200μm (0.008")	380μm (0.015")	600μm (0.024")	<7 @ 0.82μm	0.22	25MHz	6.9 x 10^8 Nt/m^2 (100,000 PSI)
VI	Step (PCS)	200μm (0.008")	300μm (0.012")	600μm (0.024")	<10 @ 0.82μm	0.26	25 MHz	6.9 x 10^8 Nt/m^2 (100,000 PSI)
VII	Step (PCS)	200μm (0.008")	400μm (0.016")	500μm (0.020")	<50 @ 0.66μm	0.22	20MHz	6.9 x 10^8 Nt/m^2 (100,000 PSI)
VIII	Step (PCS)	300μm (0.012")	440μm (0.0176")	650μm (0.026")	<7 @ 0.82μm	0.22	20 MHz	6.9 x 10^8 Nt/m^2 (100,000 PSI)
IX	Step (PCS)	400μm (0.016")	550μm (0.022")	850μm (0.034")	<7 @ 0.82μm	0.22	15MHz	6.9 x 10^8 Nt/m^2 (100,000 PSI)

LSI synthesizer family brings low-cost versatility to rf comm



Motorola Semiconductor Products, P.O. Box 20912, Phoenix, AZ 85036. (512) 928-6899. P&A: See text; stock.

A new family of LSI one-chip synthesizers will be inexpensive enough to figure in a wide range of rf-communications equipment: avionics, land-mobile, marine, amateur and consumer. With SSI or custom-chip cost barriers eliminated, the synthesizer chips can be used to reduce the high parts counts resulting from the use of tuned circuits and multiple crystals.

Versatility is the chief attribute of the silicon-gate CMOS family, with such features as down mixing, fixed prescaling or dual-modulus prescaling. While the first two devices are programmed with a clocked, serial input bit stream, the five additional devices, slated for introduction later this year, will offer parallel and 4-bit data-bus programming.

Typical frequency range extends to over 25 MHz. When required, frequency expands to over 500 MHz with the addition of existing high-frequency dual-modulus prescaling ICs.

Other family features include a crystal reference oscillator, a reference divider, a digital phase detector, lock-detection circuitry and programmable divide-by-N counters. The reference oscillator serves as an input buffer when an external reference source is used.

The MC145155 allows selection of any one of eight reference divider values from 16 to 8192. Combined with a loop filter and a VCO, the circuit provides all the remaining functions for a PLL synthesizer operating at up to the device's frequency limit. The MC145156 contains on-chip control logic to provide a modulus-control signal for use with external dual-modulus prescaling ICs.

In plastic and in hundred quantities, the MC145155 will cost $4.95 and the 145156 will cost $5.43.

CIRCLE NO. 302

Look into LEWISystems®

To organize, economize and maximize efficiency. For storage, shipping and handling. Hundreds of sizes, shapes and accessories in stock to fit all needs. Immediate shipment. Send for FREE Product Selection Guide.

LEWISystems®
MENASHA CORPORATION
426 MONTGOMERY ST., WATERTOWN, WI 53094
(414) 261-3162

CIRCLE NUMBER 43

Two-way power divider keeps 30-dB isolation

Sage Laboratories, 3 Huron Dr., Natick, MA 01760. (617) 653-0844. $115; 4 wks.

A two-way power divider, Model FP2562, offers better than 30-dB isolation between outputs in the 5.94 to 6.41-GHz range. Typical insertion loss is 0.1 dB; VSWR, 1.15 maximum. The unit measures only 1 × 3/4 × 1/2 in.

CIRCLE NO. 386

PROM manufacturers care what programmer you use.

Every domestic PROM manufacturer evaluates our programmers, so you get PROMs programmed exactly to vendors' specs.

Our U.L. listed Series 90 PROM programmer consists of interchangeable plug-in PROM personality modules and a control unit. To keep the system current and to insure programming reliability, we constantly work with the engineering departments of all domestic PROM manufacturers. They inform us of important new programming algorithms and PROM technologies. Thus, as new PROMs come along or as old PROMs change their algorithms, we can quickly develop a new PROM personality module or modify an existing one. We routinely submit each module to the PROM manufacturer to evaluate our design and test our programming. We have secured vendor approval on modules for practically every PROM currently in use.

We have modules for specific PROMs, for whole PROM families and for gang programming 8 PROMs simultaneously. We also have a generic module for MMI PALs.

Backed by a 2-year warranty.

Based on the field-proven reliability of 5,000 PROM programmers and 10,000 personality modules, we provide a 1-year parts and labor warranty on modules and a 2-year parts and labor warranty on control units.

Learn more from our 96-page PROM User's Guide.

A definitive work including cross reference charts on PROMs and other programmable devices. Call or write Pro-Log Corporation, 2411 Garden Road, Monterey, CA 93940, phone (408) 372-4593.

PRO-LOG CORPORATION

Microprocessors at your fingertips.

CIRCLE NUMBER 44

The sensible source for your

Now, it makes economic sense to automate your receiving test stations...your in-process or final test stations...your QA audit stations...even your design engineer's workbench. Look into Systron-Donner's IEEE-488 family.

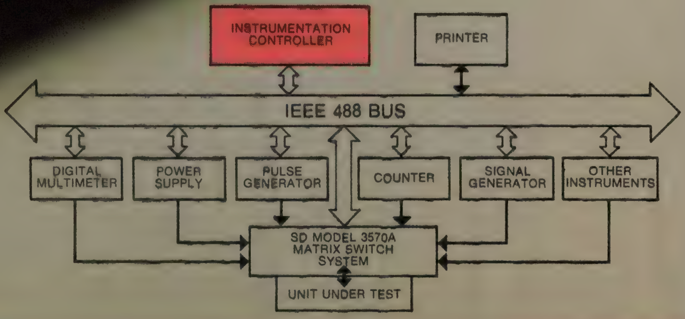
It starts with the new S-D Model 3520 BUSser. The 3520 is *specifically* designed to control IEEE-488 compatible test instruments.

The idea was to make this controller easy to use, easy to understand, easy to transport, easy to read, and easy to store programs. And that's what S-D has done by using a standard teletypewriter keyboard layout, IEEE-488 special function keys, BASIC as the programming language, and a large legible single line fluorescent display.

Program storage is simple with the PROM option. One or more programs can be stored in the PROM cartridge and erased later if desired.

Systron-Donner also made this compact controller easy to buy: $795* without PROM option, $995* with it. We put you on the bus without taking you for a ride!

Systron-Donner's IEEE-488 family



*U.S. prices

SYSTRON DONNER

PUT OUR PERFORMANCE TO THE TEST

IEEE-488 system needs.

Wide-ranging systems capability

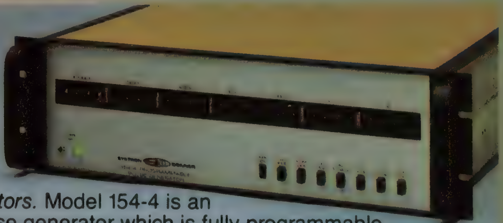
Systron-Donner's extensive line of standard, off-the-shelf IEEE-488 compatible instruments includes frequency counters, signal generators, multimeters, pulse generators, power supplies, and a precision DC voltage source. In addition, our Model 3570A Matrix Switch automates the interconnect, saving time-consuming operator interface.

Here is a representative but by no means complete sampling of bus compatible Systron-Donner instruments. Let us know what your exact requirements are. Contact Scientific Devices or Systron-Donner, 2727 Systron Drive, Concord, CA 94518, U.S.A.; phone: (415) 676-5000.

Frequency Counters. S-D's wide selection of IEEE-488 compatible counters ranges from 100 MHz all the way to 26 GHz. Model 6043A shown here is one of several thin-line designs with bus interface standard. This 1,250 MHz counter is ideal for communications work and other frequency measurement applications. Note front panel lights that tell the operator the status of the instrument while it's active in the system.

Signal Generators. One of S-D's most popular signal generators is the Model 1702 which provides a range of 100 Hz to 999.999 MHz in a single range with 100 Hz resolution. It's fully programmable on the IEEE-488 bus. For microwave frequency applications, Models 1618 and 1626 extend coverage to 18 and 26 GHz respectively.

Digital Multimeters. Systron-Donner's 4½ and 5½ digit multimeters for systems use include the Thin Line Model 7344A pictured here. This 4½ digit autoranging DVM includes the bus interface, DC volts, resistance, true RMS as standard. In the 5½ digit category, consider Model 7115 with microprocessor control, auto-calibration, and automatic fault detection and isolation.



Pulse Generators. Model 154-4 is an automatic pulse generator which is fully programmable with its IEEE-488 interface and the Model 3520 Controller. Model 154-4 provides a repetition rate of 10 Hz to 50 MHz, pulse delay and width from 10 ns to 10 ms, and outputs of 0.5 to 10 V within a −10 to +10 volt window. An exceptionally versatile instrument for the systems user.

Systems Power Supplies. Systron-Donner's P series of power supplies receives its bus commands via the S-D Programmer module shown here. Controls up to 6 supplies. One DAC board controls V, I, and V limit. Modular flexibility allows anywhere from 50 to 500 watts.

S-D: the IEEE-488 systems people.
And a lot more.

CIRCLE NUMBER 45 FOR LITERATURE

CIRCLE NUMBER 46 FOR DEMONSTRATION

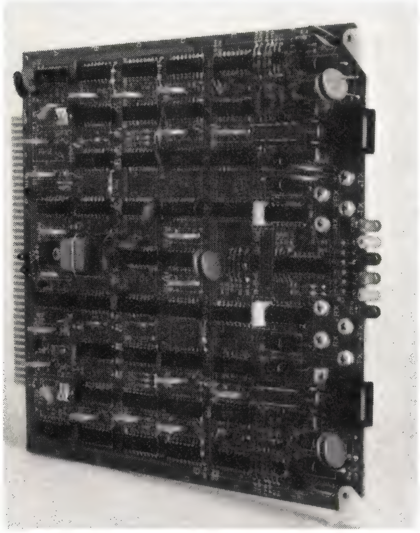
Convert rf input signal to 12-bit digital word

Anaren Microwave, 185 Ainsley Dr., Syracuse, NY 13205. (315) 476-7901.

A line of digital frequency discriminators (DFDs) measures the frequency of an rf input signal and generate a 12-bit, TTL-compatible digital output word. Measurement is accomplished on a single rf pulse as short as 100 ns without prior knowledge of time or arrival or frequency. The units operate as an adjunct to radar warning receivers and in active jamming applications. The line of 13 models includes a wideband 7.5 to 18-GHz unit, Model 182190, and five octave-band models, Series 182185 through 182189. An optional preamplifier package includes an isolator, protective limiter, filtering and a limiting rf amplifier.

CIRCLE NO. 320

Modem card helps support terminals at 9600 baud



DEI Teleproducts, 563 N. Citracado Pkwy., Escondido, CA 92025. (714) 743-8344. 8 to 9 wks.

A dual-channel, programmable, limited-distance modem card, DCCI, helps the Memorex 1270 communications controller support asynchronous terminal devices at up to 9600 baud. The board replaces the standard EIA modem interface module in the 1270 and connects to remote terminal sites through four-wire metallic circuits. The device can be programmed to operate synchronously at 2400, 4800, 9600 or 19,200 bits/s.

CIRCLE NO. 321

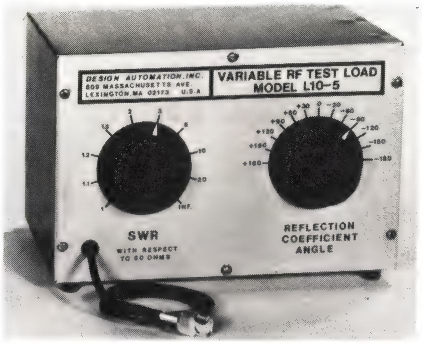
Portable test set measures fiber optic link levels

Bowmar, 531 Main St., Acton, MA 01720. (617) 263-8365.

A portable fiber-optics level test set, Model 650, measures link attenuation and can be set up for rapid go/no-go testing. Test range is 0 to 50 dB in 10-dB steps. Repeatability is better than 1% with accuracy at ±0.5 dB from 0 to −30 dB and ±1 dB from −30 to −50 dB (0 to 50 C). Fiber size is 125 μm but adapters are available for other sizes. A LED emitter, operating at 900 nm, is positioned within the transmitter portion to provide a plane wave. Attenuation in dB or absolute light level in dBm is indicated on front-panel meter. A LED indicates go/no-go status where quantitative measurements are not required. A battery charger is built-in.

CIRCLE NO. 322

Variable load aids rf amplifier tests


DESIGN AUTOMATION, INC. 809 MASSACHUSETTS AVE. LEXINGTON, MA 02173 U.S.A.
VARIABLE RF TEST LOAD MODEL L10-5
SWR
WITH RESPECT TO 50 OHMS
REFLECTION COEFFICIENT ANGLE

Design Automation, 809 Massachusetts Ave., Lexington, MA 02173. (617) 862-8998. $285.

A variable 10-MHz test load, Model L10-5, helps determine rf power amplifier or transmitter performance. Ten switch-selectable values of SWR, from unity to infinity, and continuously variable coverage of all 360° of reflection coefficient, are available. Depending on SWR value the test load can dissipate from 5 to 20 W. Other standard test loads are offered from 1 to 100 MHz.

CIRCLE NO. 323

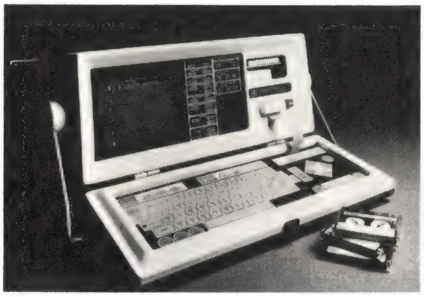
SIP amplifiers span 5 to 1000 MHz

Alpha Optimax, P.O. Box 105, Advance Lane, Colmar, PA 18915. (215) 822-1311.

A series of encapsulated rf and microwave amplifier modules, Cermods, covers frequencies in the 5 to 1000-MHz range. The devices are built to the requirements of MIL-Q-9858A and MIL-STD-883. Model CM-151 covers to 150 MHz with 15-dB minimum gain and +5-dBm power output (at 1-dB compression point). Noise figure is 7.5 dB maximum. Model CM-501 covers to 500 MHz with similar specs. Model CM-1001 ranges to 1 GHz with 12-dB minimum gain and an 8-dB noise figure. All models draw 15 mA from a 15-V supply. Size is 0.6 × 0.6 × 0.15 in.

CIRCLE NO. 324

No experience needed to operate data-comm tester

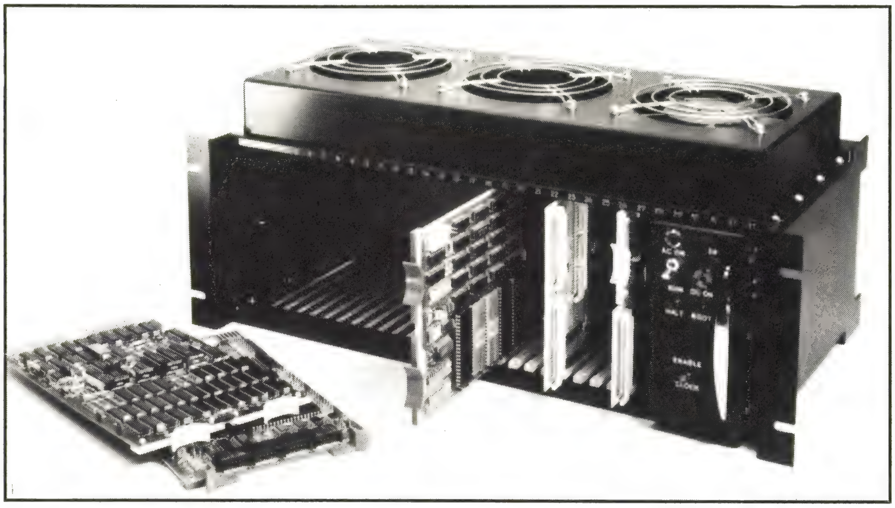


Atlantic Research, 5390 Cherokee Ave., Alexandria, VA 22314. (703) 642-4000.

Simplicity of operation and self-teaching capability make Interview 3000 series data communications analyzers a choice for the novice operator. Self-teaching displays, a color-coded keyboard and three training tapes help the user "walk through" details of the units' operation. The series has two basic models, Interview 3000 and Interview 3500 with integral tape drive. On both models, a microprocessor-prompted menu displays operator choices on a 7-in., 640-character CRT. For added versatility, the real-time monitors permit nonsequential programming. This eliminates the need to learn programming techniques such as jumps, subroutines, interrupts or macro-instructions. The user specifies a "trigger" condition that will cause a desired action. Eight independent triggers are available to sense any combination of characters, interface leads and internal flags. Data tapes hold 4 Mbits.

CIRCLE NO. 325

Enclosure 'racks up' Q-bus systems on reduced power



North-Atlantic-ACS, Inc., 60 Plant Ave., Hauppauge, NY 11787. Ken Salz (516) 582-6500. P&A: See text.

The Microchassis (MCC-1) enclosure not only contains all the elements to build microcomputer systems based on Q-bus-compatible boards but also expands to 33 card spaces with vertical mounting and vertical air flow for cooling. First of a family of circuit enclosures for DEC's LSI-11 and Q-bus-compatible compatible products, the MCC-1 mounts in a 19-in. equipment rack and occupies only 7 in. of vertical space without the need for forced air fans.

What's more, the vertical mounting enables natural convection to help cool the cards. And with the forced air cooling vertically, several MCC-1 enclosures can be stacked within an equipment rack. Indeed, cooling for up to six units comes from just two sets of fans—one beneath the bottom enclosure, one atop the uppermost one. This reduces both power consumption and overall equipment height for the system.

Each enclosure also permits easy access to circuit boards. Since the enclosure is front-loading, any card can be slid forward and removed or, with the aid of a card-extender, connected to the system for oscilloscope probing and component interchange. what's more, in-circuit modification can be done without removing the entire chassis and multiple cards can be tested without blocking off access to enclosures above and below the board being tested.

Designed to provide up to 33 card spaces on 1/2-in. centers and hardware connection to 12 cards, the enclosure can also accommodate 100-pin wire-wrapping cards for prototype work as well as a North-Atlantic-ACS plug-in power supply, which occupies three card spaces. Available switching power supplies provide a variety of 12 and 5-V ratings up to 250 W.

Connections to other enclosures can be made directly from the printed-circuit Q-bus backplane, which eliminates the need for any special PC board and related cabling requirements. In addition, control buttons located on the front panel include clock enable, run and boot, as well as an on/off switch and fuses for the power supply. These controls can be used to activate the entire system circuit board.

One MCC-1 with a 100-W power supply and hardware for 12 Q-bus-compatible cards lists for $1195. Availability is 30 to 45 days.

CIRCLE NO. 303

ELEVAM

DISCHARGE TUBES
FOR RELAYS AND
SERGE ABSORVER

Introducing a new surge absober in a low cost

● **CHARACTERISTICS**

(1)The stable character is always kept on avoiding at being influenced by the envirmemental conditions.

(2)Even if this type that has an advantage of gas discharge phenomena gets shocked and shocked a little later on, it is endurable and renewable, however, a semi-conductor isn't.

(3)Being able to know how the conditions go visibly.

(4)For customers, this can be varied with their usage.

● **FEATURES**

Lamp Type		SA 80	SA 140	SA 200	SA 300	SA 350
Starting Voltage (vac)		70 ~ 90	130 ~ 150	160 ~ 240	250 ~ 350	350 ~ 400
External Resistance (K-ohms)		33	75	100	150	150
Normal Current (mA)		1.6	1.0	1.7	1.6	2.0
Outline and Dimensions (m/m)	oveall length	20	25	20	20	20
	die-mter	6.5	6.5	6.5	6.5	6.5

● **MAIN PRODUCTS**

Glow Lamps, Color Light, Xenon Flash Tube, Black Light, and UV-Light.

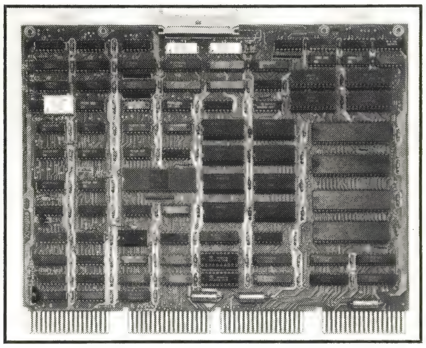
ELEVAM
ELECTRONIC
TUBE CO., LTD.

For further information.

No. 17-8, 2-chome, Chuo.
Ohta-ku, Tokyo, Japan.
Telephone (03)774-1231
Telex: 246-8855 ELEVAM.

CIRCLE NUMBER 47

Smart disk controller gives 40 Mbytes of storage



Xylogics, Inc., 32 Third Ave., Burlington, MA 01803. Harland LaVigne (617) 272-8140. $1875 (single quantity); 30 to 45 days.

The Model 530 intelligent Winchester-disk controller stores up to 40 Mbytes for any DEC computer that employs the Q-bus, including the LSI-11/2 and 11/23, and is completely software-compatible with operating systems that use RL01/RL02 support.

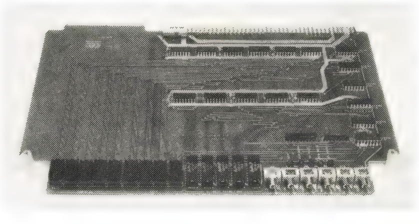
The entire disk-controller interface resides on a single, two-sided, quad-width, printed-circuit board that measures 8-1/2 × 10 in. Throttle and interleaving techniques synchronize each disk drive to the Q-bus commands and eight-sector buffering. A bit-slice microprogrammable processor and Xylogics' Micro Module approach to controller design facilitate expansion.

With the expansion techniques, non-Winchester-disk drives can be handled with on-board ROM changes. The controller allows the system storage capacity to be expanded to 960 Mbytes.

The 530 works with most Winchester-disk drives, including the BASF 24-Mbyte and IMI 10-Mbyte 8-in. drives and the 14-in. Century Data Marksman. The 530 supports self-boot, ROM-boot and bootstrap operations and gives 100% position verifications.

CIRCLE NO. 304

Display board gives view of Multibus operation



Zendex, 6398 Dougherty Rd., Dublin, CA 94566. (415) 829-1284. $250; 2 to 4 wks.

A bus display board, ZX-906, aids software and hardware debugging of Intel's SBC and other Multibus compatible systems. The board plugs directly into a Multibus backplane and gives a full 20-bit address and 16-bit data display of activities on hexadecimal LED readouts. The unit can be set to display memory and I/O or read/write cycles. Data sent to or read from a port or memory address can be latched "on-the-fly." A bus extender is included to adapt the display to an SBC-604/614 chassis when the chassis is fully loaded. Power supply requirement is 5 V at 1 A typical.

CIRCLE NO. 384

PTK lights CRT's

HIGH VOLTAGE FOR CRT APPLICATIONS

COMMERCIAL
2 to 30kV, 3 to 30 watts, high voltage power supplies. Custom flyback transformers.

→ C-100 Series

MILITARY
Mil grade units for ground, ship and aircraft.

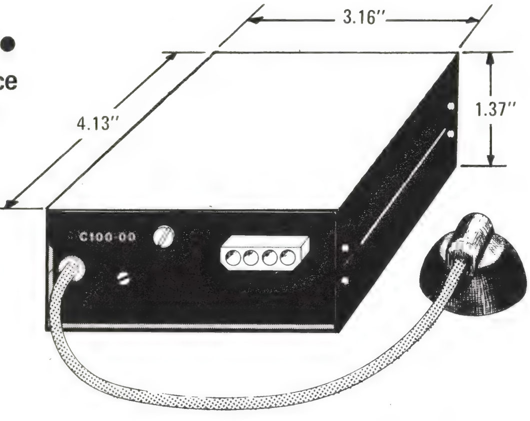
L.V. / H.V. COMBO'S
High voltage power supplies combined with a multiple output low voltage switcher.

SPECIALS
Miniature and sub-miniature high voltage power supplies to 20kV. Ultra stable or ultra low ripple designs.

H.V. CONNECTOR & LEAD ASSEMBLIES
Amp LGH types to 20kV.

For technical assistance or pricing call Wayne Hamari toll free (outside California) 1-800-235-4148

MAJOR FEATURES:
Low Cost • 2 to 22kV at 10W • Excellent Transient Performance • Focus and G1 Bias Voltages to ±1kV • Standard Input +26V ±10% • Demonstrated MTBF > 100,000 hours • UL Recognized for Medical Applications • Input, Output Mounting and Connector Options available •
3 YEAR WARRANTY



PTK Corporation 1173 Los Olivos Avenue, Los Osos, CA 93402 (805) 528-5858

CIRCLE NUMBER 48

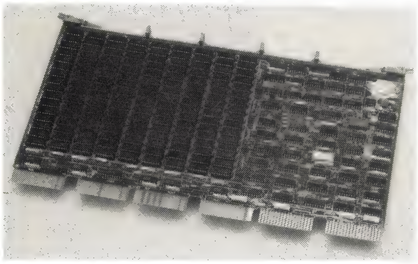
Prototyping kit yields high resolution graphics

DOSC, 175 I. U. Willets Rd., Albertson, NY 11507. (516) 621-6640. $1450 (10 qty); stock.

A dual-board prototyping kit, SVB-80P, produces high-resolution graphics in an Intel Multibus configuration. Displays of 640 × 409 or 576 × 455 pixels are possible. Alphanumerics are displayed in 80 × 40 or 72 × 44 format with graphics and alphanumerics intermixed. Monitor software allows the system to go "on-line" immediately. The kit contains the SVB-80 Soft Video Board and the MIB-85 Memory Intensive Board.

CIRCLE NO. 326

Plug-in board boosts PDP-11 memory



Mostek, 1215 W. Crosby Rd., Carrollton, TX 75006. (214) 242-0444. $3600.

A 128 kword × 18 bit single card memory system, MK8012, plugs into a core or semiconductor slot on a variety of DEC PDP-11 computers. Density options include 64-k × 18, 96-k × 18 or 128-k × 18. There is also a parity option. The board carries a one-year warranty.

CIRCLE NO. 327

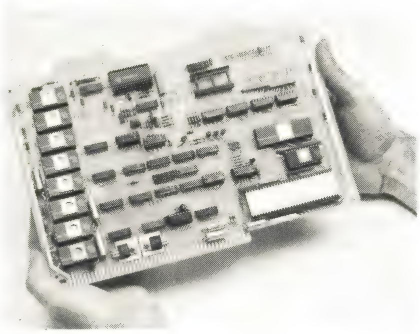
Memory add-ons enhance printer operation

Tri-Data, 505 E. Middlefield Rd., Mountain View, CA 94043. (415) 969-3700. $600 (4-k); $800 (16-k); 8 to 9 wks.

Single circuit-board memory units enhance the versatility of Teletype Model 43 and DEC LA/34 and LA/36 teleprinters. Buffer storage devices, the units receive data for editing and retransmission. An on-line power-up feature permits unattended printing of incoming reports. Keyboard programmable control of baud rate permits incoming data to be spooled at 1200 baud while sending at a normal rate of 300 baud.

CIRCLE NO. 328

Speech module joins TM990 μC family



Texas Instruments, P.O. Box 1443, MS-6404, Houston, TX 77001. (713) 494-5115. $1280.

A speech synthesizer module, TM990/306, offers a basic industrial vocabulary of over 160 words. The module joins over 60 other TM990 microcomputer module boards. The speech unit provides verbal instructions or signaling as an alternative or replacement for indicator lights or audible alarms. Included within the board's capabilities are numbers from one to twelve and the alphabet from A to Z. An on-board amplifier drives an 8-Ω speaker with a 2.5-W output. In polled-status mode, a host CPU issues the addresses of a word, sets the talk command and polls the status bit to determine when a word has been spoken.

CIRCLE NO. 329

Controller links Unibus to Winchester disk drives

Microcomputer Systems, 432 Lakeside Dr., Sunnyvale, CA 94086. (408) 733-4200. $4850; 8 to 13 wks.

An intelligent, single-board controller, MSC-1101, interfaces DEC's Unibus to Winchester and other standard SMD interface, high-capacity disk drives. Intended for users of the PDP-11 and VAX series computers, the controller extends to minicomputers the I/O processing techniques previously available on large, mainframe computers. Standard features include command chaining, automatic error correction and retry recovery, implied overlapped seek, automatic head and cylinder switching and DMA load regulation. Two-drive, dual-port control is also standard. The MSC-1101 plugs directly into a single backplane slot. Software integration packages are available for RT-11, RSX, IAS, RSTS/E and VAX/VMS operation systems.

CIRCLE NO. 330

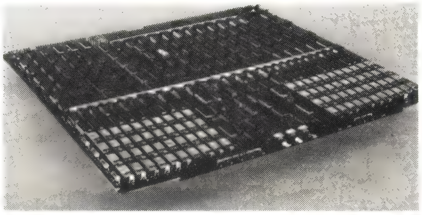
CPU board splits memory for easy data handling

Central Data, P.O. Box 2530, Station A, Champaign, IL 61820. (217) 359-8010. $995.

A Multibus CPU board, based on a Z8001, 16-bit microprocessor, divides its 16-Mbyte memory for more efficient data handling. The memory is sectioned into 2-k pages. Pages are mapped to make 16 independent address spaces available on the system. Each space has a 4-Mbyte maximum size. Each page can be write-protected to assure data integrity. Shared pages are possible between different, independent address spaces. Support chips, including a programmable interval timer and a programmable interrupt controller, decrease main processor workload. Options include a 9511 arithmetic processor and two 2716 EPROMs for monitor or bootstrap programs. The entire board operates from a single 5-B supply. Use of the 9511 requires a 12-V supply.

CIRCLE NO. 331

Add-on gives cache and ECC to Eclipse computer



Intel, 3065 Bowers Ave., Santa Clara, CA 95051. (408) 987-8080. $4500; 6 to 7 wks.

A multifunction memory board, Model 5150, adds on-board cache memory and error checking circuitry (ECC) to Data General's Eclipse minicomputers. The 5150 stores up to 64 kwords (128 kbytes). On-board cache memory permits a 200-ns data access time, resulting in an increase in program execution speed. Interleaving capability allows a processor to access data from several memory boards simultaneously. Each board generates its own control signals and can operate asynchronously. Jumper provisions allow up to eight-way interleaving. In addition to ECC with single-bit correction capability, the 5150 features error logging and display, address select DIP switches and low power dissipation—65 W while operating and 50 W in standby.

CIRCLE NO. 332

Tell it and forget it...

. . . the new CY500 stored program stepper motor controller runs its own program, freeing your host computer for other jobs.

No more one-pulse, one-step operation requiring your host computer to tie itself down to a stepper motor. Now Cybernetic Micro Systems brings you a function-oriented stored program stepper motor controller that allows the user, or host computer, to program it and forget it . . .

The CY500 executes 22 hi-level instructions, either in command mode or as a sequence of internally-stored commands, using single byte code such as 'P' for position, 'R' for rate, and 'S' for slope. Parameter values can be expressed in ASCII-decimal for keyboard programming or binary code from the host computer. Parallel or serial communication.

The stored program capability allows the use of 'DO-WHILE' program looping and 'WAIT-UNTIL' operation. Ten different operational modes allow absolute or relative positioning, full- or half-step operation, hardware or software control of direction, start/stop, . . . and many more.

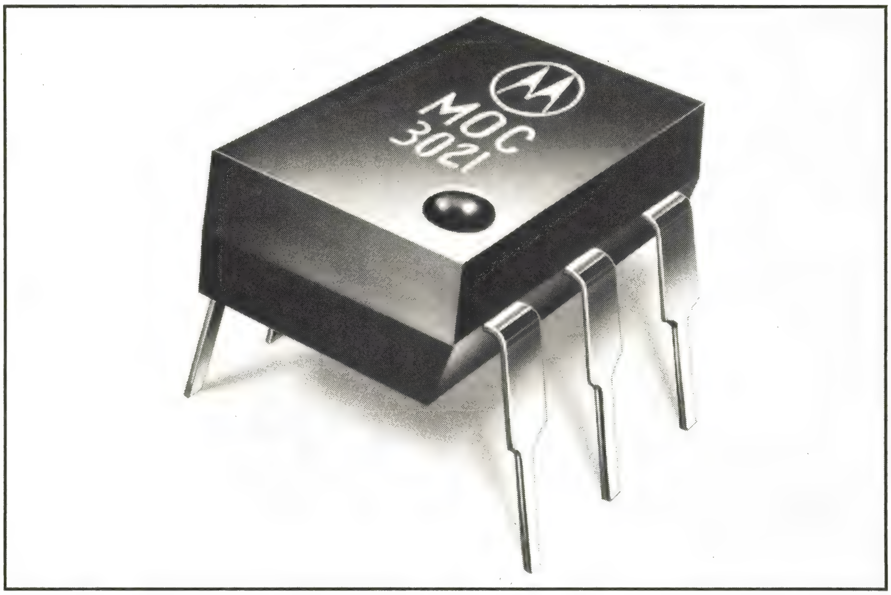
Numerous input and output control lines allow synchronizing the CY500 with external events or devices and allow each step to be triggered. Stepping at rates up to 3500 steps/sec, the CY500 also provides ramp-up, slew, and ramp-down operation, all under software control. Two interrupt lines request the host's attention if needed.

This +5 volt N-MOS TTL-compatible controller is available from stock, today, for only $95.00. Contact Cybernetic Micro Systems. We want to see you program your stepper motor and then . . . forget it.

Cybernetic Micro Systems
445-203 South San Antonio Road
Los Altos, California 94022
(415) 949-0666

(Use your MASTER CHARGE or VISA charge card) **CIRCLE NUMBER 49**

Triac drivers provide logic control on 220-V ac lines



Motorola Semiconductor Products, P.O. Box 20912, Phoenix, AZ 85036. P&A: See text; stock.

Two optically isolated triac drivers from Motorola Semiconductor Products extend the advantages of logic-level control to equipment operating from 220-V ac lines. The drivers differ only in their required latching current; 30 mA for the MOC3020 and 15 mA for the MOC3021. Both have a blocking voltage of 400 V and a minimum isolation voltage of 7500 V.

The optocouplers drive virtually any triac. Interest in the devices is expected from U.S. designers of industrial controls and of equipment powered from 220-V ac lines, as well as from Europe, where 220-V ac power is widespread. Applications suggested by Motorola indicate the product's usefulness even in circuits controlling 115 V ac.

Within a six-pin plastic DIP is a gallium-arsenide, infrared-emitting diode, optically-coupled to a silicon bilateral switch. The drive portion of the coupler does not require a separate power supply. It derives its gate current from the power triac connected directly across an ac line. The triac driver is equally comfortable switching either the "hot" leg or the neutral leg of an ac line. The driver usually fires a power triac in quadrants I and III, characteristically the most sensitive.

Deriving the triac gate current from an ac line has an added advantge: The coupler and a power triac can be located at the load itself. Only low-voltage current lines for the LED need be routed back to a central controller. In many instances, the lines would not need shielded metal conduits.

Output drive current is 100 mA rms at 25 C. Peak nonrepetitive surge current is 1.2 A for a 10-ms pulse. Operating temperature range is −40 to +70 C. The devices are UL recognized, File No. E54915.

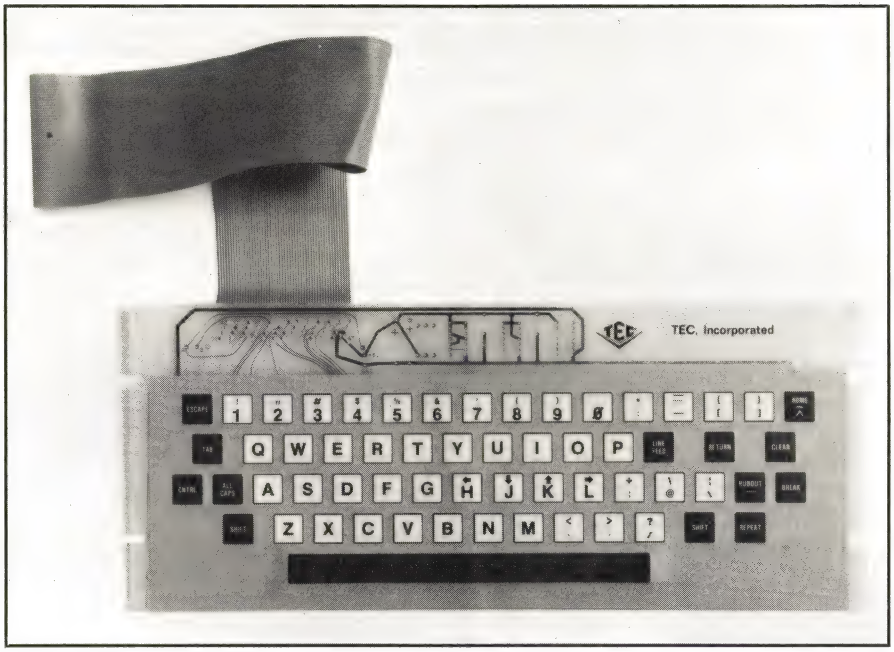
With a peak V_{DRM} of 400 V, the optocouplers supply an important advantage in 115-V ac circuits. For example, a dual-winding, reversible ac motor will induce a voltage in one winding as the other is being used. This voltage can come dangerously close to, or at times exceed, the 250-V rating of previous devices. The new optocouplers supply an added safety margin.

Because they are non-zero-crossing triac drivers, the devices will operate in series. Two or more drivers, so wired, operate independently to form an AND. This permits row/column access for large-load drives.

In quantities of 1000, the MOC3020 costs $1.25; the MOC3021, $1.50.

CIRCLE NO. 305

Keyboard smartens up for process control



TEC Inc., 2727 N. Fairview Ave., Tucson, AZ 85705. Roy Dennis (602) 792-2230. P&A: See text.

Smart or dumb, TEC's micromotion keyboard with full alphanumeric notation withstands the hazards of industrial process-control applications. Its membrane-technology keyswitches feature stainless-steel contact domes with less than 1-ms bounce and more than 5-million cycle lifetimes.

Keys are placed on 3/4-in. centers and row-staggered in the conventional manner. Requiring 6-oz of operating force, the keys have a travel range of 20 mils, which ensures tactile feedback to the operator.

Contact ratings for the dumb version of the MMK keyboard are 50 mA and 28 V dc resistive; high-voltage breakdown is 250 V ac at a frequency of 60 Hz.

Smart keyboards require +5 V dc at 300 mA and −12 V dc at 50 mA. Output lines are driven to TTL levels or CMOS levels and input lines are activated at TTL levels; both output and input are logically true.

The smart version of TEC's micromotion keyboard provides on-board scanning, data encoding, mode latching, parity generation, two-key rollover, output strobe and, as an option, one-character memory.

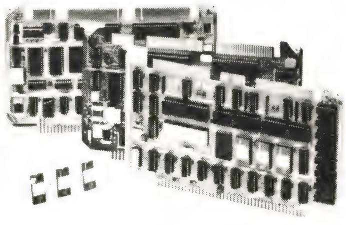
The 60-key array can output 128, 8-bit codes. Shifted, unshifted and control modes determine the coding of the keyboard's output word. Depressed-key encoding conforms either to ASCII or the EBCDIC character codes.

In operation, the keyboard electronics scan the BO keyswitch array. When a depressed switch is detected, a strobe notifies the host processor and the activated switch address is encoded into a data byte. The keyboard can be functionally disabled with a signal from the host processor, blocking all data bits and strobes.

Ordinarily, bus connections to the host system are made by flexible connectors with Spectra-Strip 800-579 headers, although direct soldering and pc-board tabs are also used. The keyboard fits into a 12-1/2 × 4-in. panel cutout, mounts by four screws and needs no further mechanical support at all.

Thousand-unit pricing on the dumb version of MMK Keyboards is $30; delivery is 30 to 45 days. Thousand-unit pricing on the smart version is $65, and delivery is 10 weeks.

CIRCLE NO. 306


6809

6809
MONOBOARD COMPUTERS
EXORCISERS*/MICROMODULE* BUS

MIKUL 6001
DEBUG/MONITOR MODULE

MIKUL 6809-2
2 PIAS, 2 ACIAS, 2 K RAM
(BATTERY BACKED), 4/8 K EPROMS

MIKUL 6809-3
1 PTA (6840), 2 PIAS, 1 ACIA, 2 K RAM
(BATTERY BACKED), 4/8 K EPROMS

OTHER EXORCISER*-COMPATIBLE
BOARDS AVAILABLE

TL INDUSTRIES INC.
2573 TRACY ROAD
NORTHWOOD, OHIO 43619
(419) 666-8144

*Trademark of Motorola

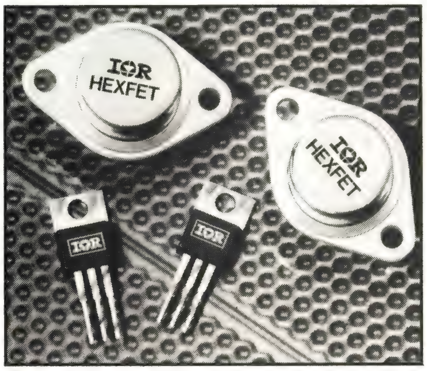
CIRCLE NUMBER 50

J FOR JOB

OPPORTUNITIES
OPPORTUNITIES
OPPORTUNITIES
OPPORTUNITIES
OPPORTUNITIES
OPPORTUNITIES
OPPORTUNITIES
OPPORTUNITIES

TURN TO
Electronic Design's
RECRUITMENT
SECTION

MOSFET breakdown voltages climb higher—up to 500 V in two device families



International Rectifier, Semiconductor Div., 233 Kansas St., El Segundo, CA 90245. Brian Pelly (213) 772-2000. P & A: See text.

Still on the rise, MOSFET drain-to-source breakdown voltages have reached 500 V with the introduction of two device families from International Rectifier. The IRF430 and IRF830 transistors are rated 100-V higher than the company's IRF350 family, marketed just a few months ago. Both families use IR's HEXFET technology, which yields cost-effective power devices.

In TO-3 packages, the IRF430, 431, 432 and 433 form one series; the IRF 830 series, housed in plastic TO-220AB, comprises the 831, 832 and 833 devices. Breakdown voltages for the 430, 830, 432 and 832 are 500 V. For the 431, 831, 433 and 833, breakdown voltages are slightly lower, at 450 V.

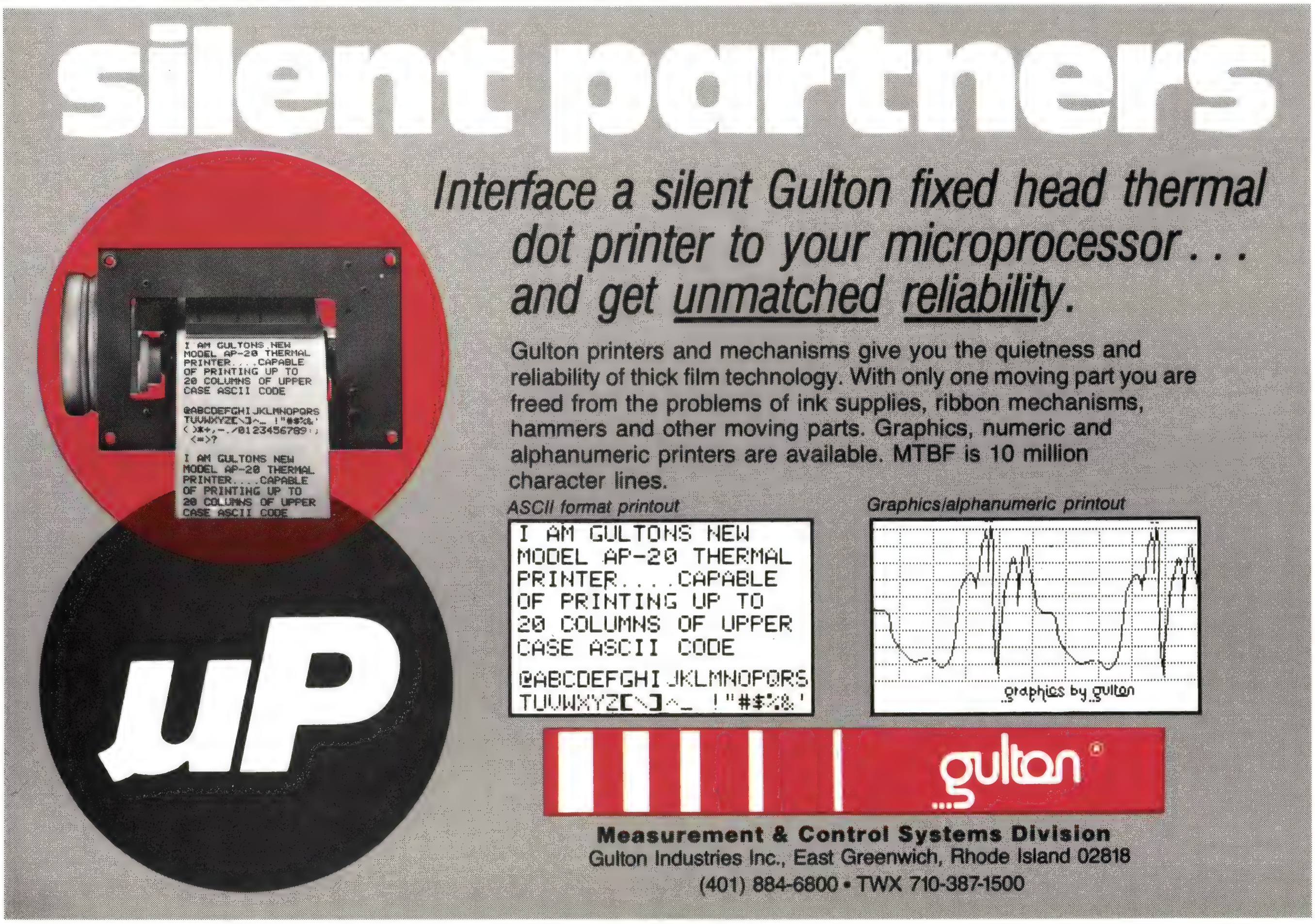
At 3.5 A, continuous drain current is greatest in the 430 and 431. The lowest current capacity—2.5 A—is found in the plastic-packaged 832 and 833 devices. In between, the 432, 433, 830 and 831 are each rated to carry 3.0 A of current.

On-resistance, a key MOSFET switching parameter, comes in at a maximum of 1.5 Ω for the 430, 431, 830 and 831, and 2.0 Ω for the others. The resistance specification, $R_{DS(ON)}$, is measured for all devices with a gate-to-source voltage of 10 V, at a 1.5 A drain current.

Power dissipation for both families is 75 W maximum, with a linear derating factor of 0.6 W/°C. Input capacitance is typically 700 pF, and forward transconductance is 1.5 siemens minimum, at 100-V drain-to-source and 1.5-A drain current.

The new devices, initially available in small quantities only, are on a four to six-week delivery schedule. For one to nine units in TO-3 packages, the price will be $22 to $28.

CIRCLE NO. 307


silent partners

Interface a silent Gulton fixed head thermal dot printer to your microprocessor . . . and get unmatched reliability.

Gulton printers and mechanisms give you the quietness and reliability of thick film technology. With only one moving part you are freed from the problems of ink supplies, ribbon mechanisms, hammers and other moving parts. Graphics, numeric and alphanumeric printers are available. MTBF is 10 million character lines.

ASCII format printout

```
I AM GULTONS NEW
MODEL AP-20 THERMAL
PRINTER....CAPABLE
OF PRINTING UP TO
20 COLUMNS OF UPPER
CASE ASCII CODE
@ABCDEFGHIJKLMNOPQRS
TUVWXYZ[\]^_ !"#$%&'
```

Graphics/alphanumeric printout

graphics by gulton

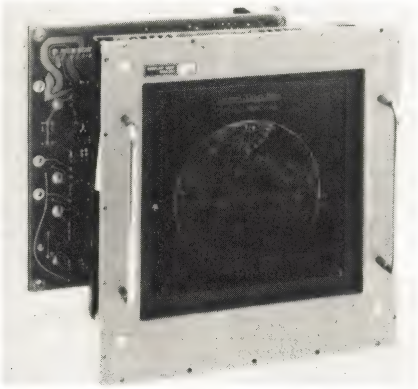
uP

gulton®

Measurement & Control Systems Division
Gulton Industries Inc., East Greenwich, Rhode Island 02818
(401) 884-6800 • TWX 710-387-1500

CIRCLE NUMBER 51

Plasma displays maintain thin behind-panel profile

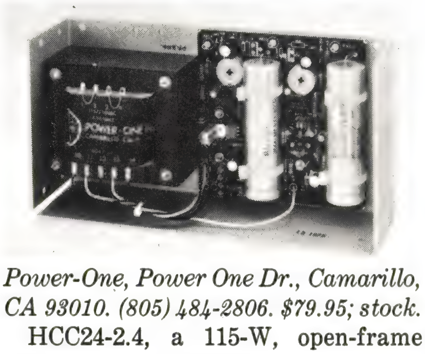


Interstate Electronics, 1001 E. Ball Rd., Anaheim, CA 92803. (714) 635-7210. $8900 (300); $7900 (301) (51 qty); stock.

Designed for OEM use, Models PDA 300 and PDA 301 flat-panel plasma displays maintain a thin-profile. Only 7-3/4 in. deep, display profile depth decreases to only 5 in. with an optional remote mounting of the power supply module. Usable display area is 8-1/2 × 8-1/2 in., with 512 × 512 individually addressable dots. The display provides 51 lines at 85 characters per line. Typical alphanumeric capacity is more than 4300, 5 × 7 matrix characters. Model PDA 300 uses 5400 series devices for military use. Model PDA 301 is intended for rugged industrial use.

CIRCLE NO. 339

OEM supply gives dual output



Power-One, Power One Dr., Camarillo, CA 93010. (805) 484-2806. $79.95; stock.

HCC24-2.4, a 115-W, open-frame power supply, delivers ±18 to ±24 V at 2.4 A. The outputs are continuously variable. Line and load regulation are ±0.05%; maximum output ripple is 5 mV pk-pk. The supply meets the shock and vibration requirements of MIL-STD-810C and measures 9.38 × 4.87 × 3.2 in. The unit is protected against short-circuit and overload conditions.

CIRCLE NO. 340

Lab power supply series satisfy varied needs

Kikusui International, 17121 S. Central Ave., Carson, CA 90746. (213) 638-6120. Stock.

A line of almost 100 lab-type power supplies offers features to satisfy many needs. PAC and PAD series supplies are constant voltage, constant current types with automatic crossover. They offer continuous, one-knob output control, remote programming, remote sensing and automatic parallel operation. PAB series economy supplies are fully protected and operate in series, parallel or auto-parallel. PDM series dual supplies are bipolar for independent or tracking operation. They are available for constant voltage or constant current applications. POW series units are bipolar power supply/amplifiers. The amplifier offers variable gain and low distortion. Bandwidth is dc to 30 kHz.

CIRCLE NO. 341

Choose the power supplies the experts choose.

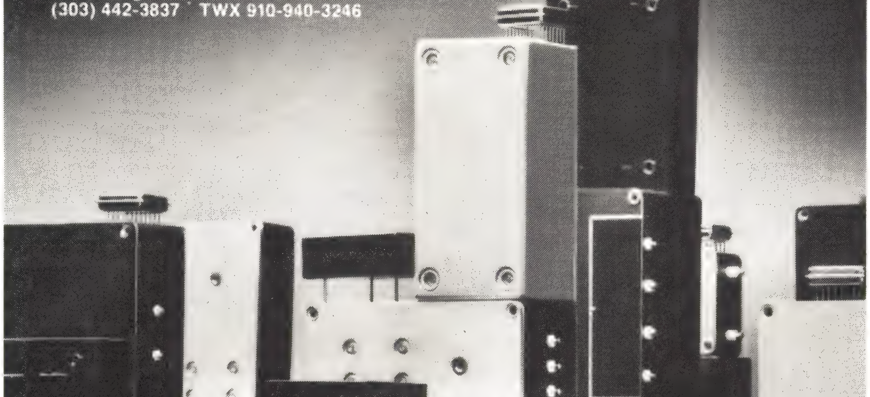
Tecnetics Incorporated is one of the leading suppliers of DC to DC power conversion units to military and aerospace markets.

Those experts come to us because of our expertise in the technology of high efficiency and reliability.

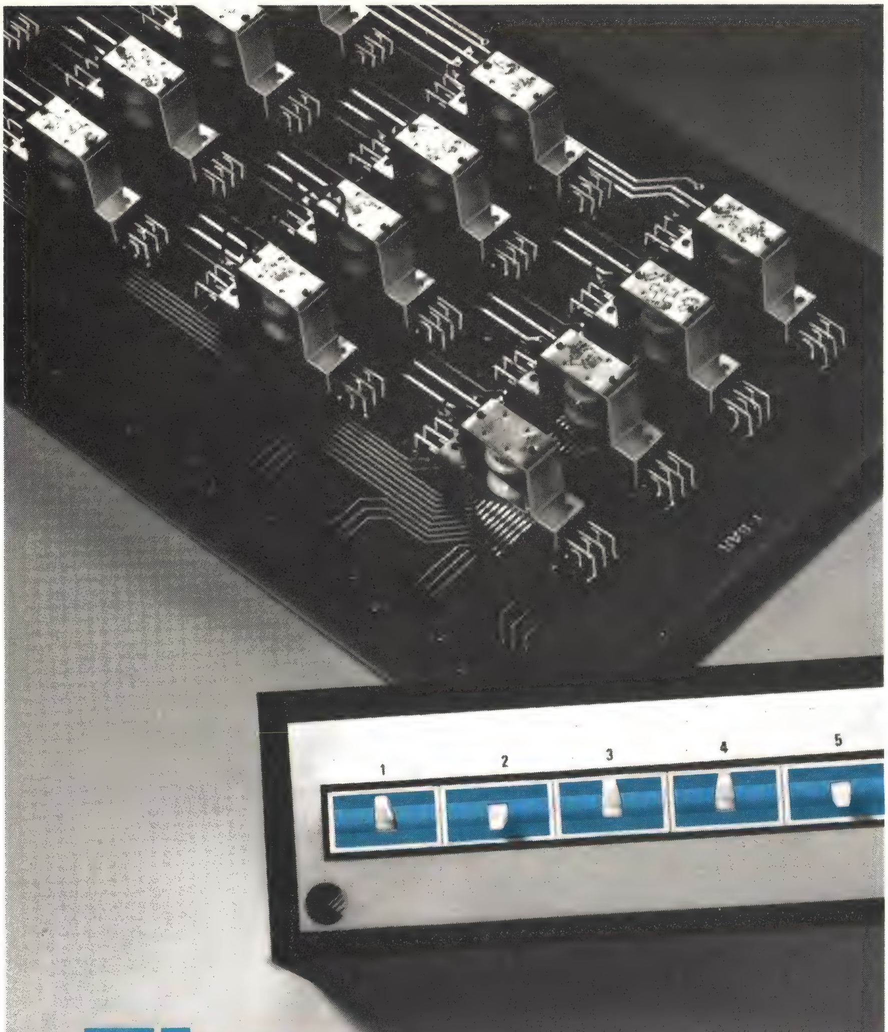
Because we design, build and test according to their highest standards. And because our products are proven under their toughest applications.

So send for the catalog the experts use—the 1980 Tecnetics Catalog. And choose from over 1000 quality DC to DC supplies.

tecnetics ®
INCORPORATED
The DC-DC Expert
1625 Range St., P.O. Box 910, Boulder, CO 80306
(303) 442-3837 TWX 910-940-3246



CIRCLE NUMBER 57



T-bar®

Reliability

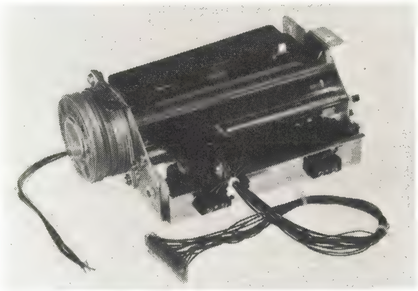
6 Pole Double Throw Miniatures

T-Bar's new 200 Series of Miniature Relays and Switches with gold contacts are specifically designed for switching low level Analog, Digital and Video data signals in Communications, Computer, Telephone and Test Equipment applications. Miniatures . . . another series of reliable switching products from T-Bar. Want to know more . . . Call or write T-Bar today.

T-bar® INCORPORATED
SWITCHING COMPONENTS DIVISION
141 Danbury Rd.
Wilton, CT 06897
203 762-8351

CIRCLE NUMBER 56

40-column printer fits terminals/instruments

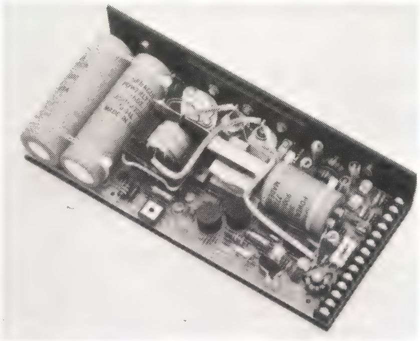


Two-Day, 1915 W. Glenoaks Blvd., Glendale, CA 91201. (213) 841-0261. $180.

A 40-column dot-matrix impact printer mechanism operates in OEM terminal, computer and instrumentation designs. The unit prints two lines each second. Size is 2-1/2 × 7 × less than 5 in. Options include stepper-motor paper control, adjustable tractor-feed for continuous forms, right-to-left printing and split-paper printing with independent paper advance.

CIRCLE NO. 342

20-kHz switching supply produces four outputs

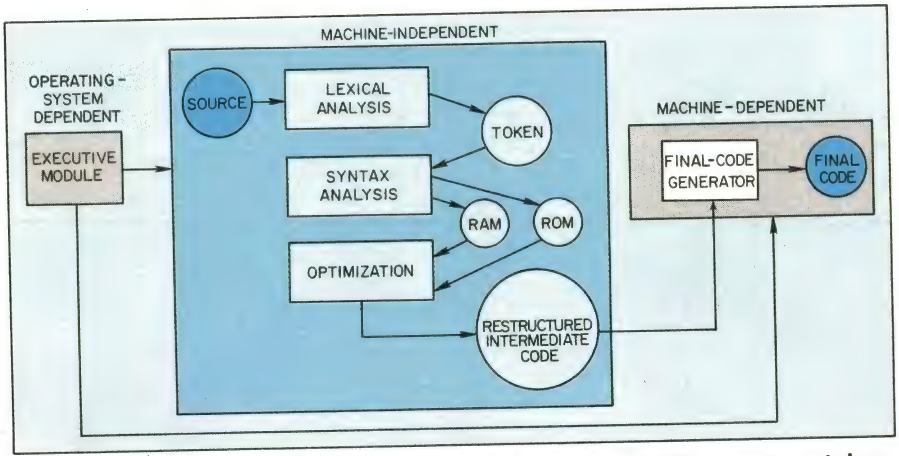


RO Associates, 246 Caspian Dr., Sunnyvale, CA 94086. (408) 744-1450. $225; stock to 4 wks.

A 20 kHz switching power supply, Model 912, produces four output voltages with a total capability of 111 W. The open-frame unit delivers 5 V at 15 A, ±12 V at 1.5 A and −5 V at 0.5 A. Line regulation is ±0.1%; load regulation, better than ±0.5%. All outputs have short-circuit and current-limiting protection. The 5-V output has remote sensing and self-recovering overvoltage protection.

CIRCLE NO. 343

Universal compiler adapts quickly to new chips



Between source and object code (both highlighted), the PLMX generates a token file and intermediate code. Only those system parts shown in gray must be changed to work with different processors.

System Consultants, Inc., 4015 Hancock St., San Diego, CA 92110. Dr. Ingber (714) 222-6381. P&A: See text.

Whenever a new μP or μC chip comes out, high-level software support is usually minimal. SCI's universal PLMX compiler—actually a language converter—fills that software gap within eight weeks after the chip's specification becomes available.

The PLMX compiler converts programs written in Intel's popular PLM language into assembly code for the target machine. It does so with the help of three modules: The Executive Module depends on the operating system (at present CP/S or TEKDOS); the Code Generator module depends on the host CPU; and the bulk of the compiler—as much as 85%—is the Machine Independent module. Conversion to a new target machine is a relatively simple job that takes several weeks, rather than months, to complete.

Under direction of the target machine's OS, the compiler first subjects the source code to lexical analysis. The source code is separated into a ROM and a RAM file—a very helpful distinction in the development of control applications. The compiler converts the code into a token file (see schematic), and the token generator is then dropped to make space for syntax analysis.

After syntax analysis, the optimization segment scrutinizes the program for inefficient code. It generates a new form of the program, called Restructed Intermediate code, which is independent of the target processor and is not accessible to the programmer. Once this code is complete, the syntax analysis and optimization segments of PLMX are no longer needed.

Since the intermediate code is universal, each μP requires its own Final Code Generator, which converts the intermediate code into standard assembly language for the target processor. Now the design engineer can add additional assembly statements, or otherwise improve the compiler-generated assembly program.

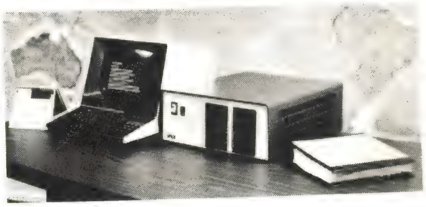
The multiple steps in program checking and conversion do take time. Compilation requires about 1 min. for every 100 PL/M statements. But execution is generally 15 times faster than under an interpreter.

One major advantage of PLMX—especially important in relation to the new 16-bit chips—is the ease with which existing software can be adapted to a new μP.

At this time, versions for the 8080, 6800, 6500 and any other μPs supported by the Tektronix 8002 are available off the shelf; development for other μPs takes eight weeks. The PLMX compiler costs $1000 for the first copy and $750 for the second.

CIRCLE NO. 308

Desktop μC includes up to 1.2-Mbyte storage



iPEX International, 16140 Valerio St., Van Nuys, CA 91406. (213) 781-0020. $3695; 4 wks.

iPEX 8085, a desktop microcomputer, uses dual floppy disk drives for up to 1.2-Mbyte storage. The CPU is based on the 3-MHz 8085 microprocessor for higher throughput than 8080-based units. The computer, however, is fully compatible with 8080 software. A standard system includes approximately 600 kbytes of on-line disk storage which can be expanded to 1.2 Mbytes. RAM, totalling 32 kbytes, can be directly expanded to 56 kbytes without use of memory management schemes. Software supplied includes a disk-extended Basic package, a disk operating system and utilities, including a debug package and a 3-kbyte PROM resident system monitor. Other software supported includes CP/M, CBasic, Microsoft Basic and Fortran-80.

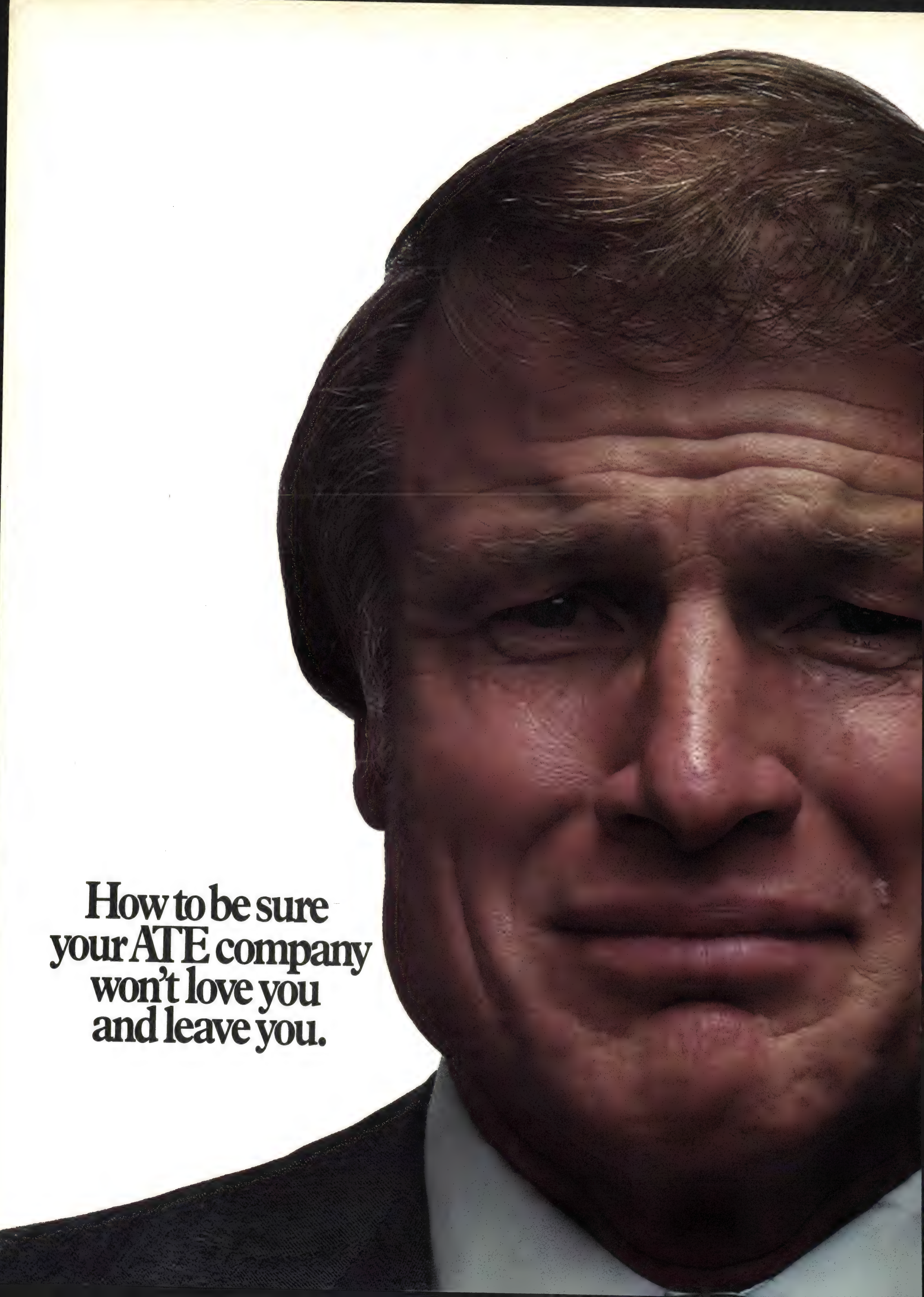
CIRCLE NO. 344

File transfer aids μC-to-μC interaction

Digtial Equipment, 129 Parker St., Maynard, MA 01754. (617) 897-5111. $1400.

A software package allows interaction between MINC or Mini-MINC laboratory computer systems and PDP-11 or VAX-11/780 computers. MINC NFT (network file transfer) is compatible with DECnet communications software. File transfers under NFT can be local-to-remote, remote-to-local and remote-to-remote. NFT can also be used for local system management tasks, such as copying, deleting and displaying local files. The NFT system has 20 commands separated into file commands, for local file operations, calendar commands, for data and time and network commands, for data transfer between systems. The software can be used with computer systems employing the RSX-11, IAS and VAX/VMS operating systems.

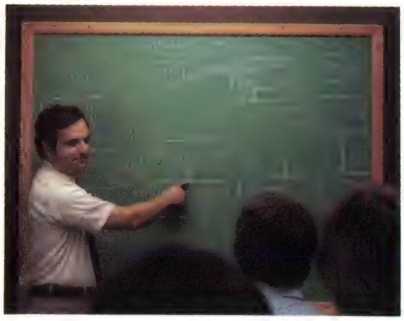
CIRCLE NO. 345


How to be sure
your ATE company
won't love you
and leave you.

The last thing you want to do is fall for a sweet-talking ATE company, and find yourself left without any visible means of support.

That won't happen if your ATE company is GenRad. That's because no other company offers you as many different levels of support.

First, you'll meet our Product Specialist. He'll take a close look at your operation and analyze your needs.

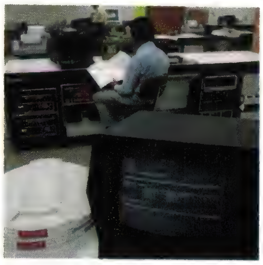


GenRad Applications Engineers work closely with your test system engineers to develop the most effective solutions to your testing problems.

Then you'll meet our Applications and Software Engineers. Their job is to fine-tune both hardware and software to your specific application.

And as your needs change, our Software Support Group is always there to help. Generating software device models and application notes, and working with you on debugging and enhancements. Just give them a call whenever you need them.

GenRad also has a lot of other people you can call on. For instance, our Training Specialists will make sure every one of your programmers understands their new system inside and out.



GenRad's Programming Services Group is always ready to off-load your programmers whenever you need help.

And our Programming Services Group, made up of full-time applications specialists, can off-load your programmers whenever you need help.

If a problem does occur, we can have a Field Service Specialist right there and solving any problem within hours of your call.

We even help you solve problems *before* they develop by putting you in touch with one of our User Groups. People like you who own and use GenRad equipment. In many cases, you'll be able to benefit from the experience of someone who's had a testing problem similar to yours.

GenRad User Groups meet often to discuss common concerns and share ideas. One user may already have an answer to a testing problem you're working on.

Altogether, GenRad offers you eight different levels of support. No other ATE company even comes close.

That's something to think about before you let an ATE company get close to you.

For details on our complete ATE line—from product development to field testing—write GenRad, Concord, MA 01742.

GenRad

Put our leadership to the test.

CIRCLE NUMBER 58

glitch \'glich\ *n* [prob. fr. German *glitschen*, to slide] **1:** Originally, an unwanted, false electronic pulse. **2:** Now, any of a variety of problems that plague both hardware and software in digital designs. syn spike, snarp.

glitchfixer \'glich fik-ser\ *n* [only from Gould] **1:** A Biomation logic analyzer with 8, 9, 16, 27 or 32 channels, sampling rates to 200 MHz, and memory lengths to 2048 words. **2:** The ultimate solution to troubleshooting digital logic.

GOULD
An Electrical/Electronics Company
4600 Old Ironsides Drive, Santa Clara, CA 95050
For a Glitchfixer catalog, call Bob Lorentzen
at (408) 988-6800

CIRCLE NUMBER 59

Off-the-shelf-rental

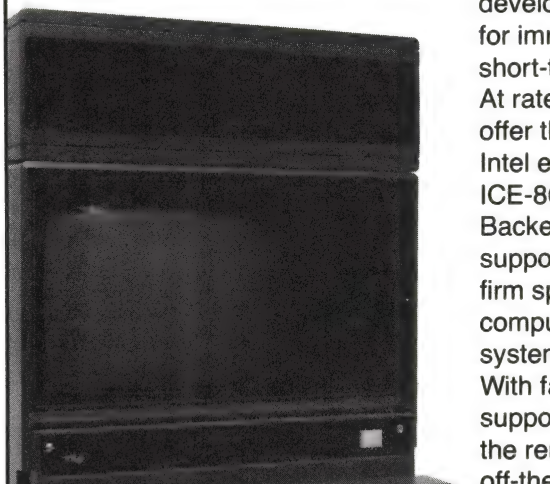
The Intel MDS microcomputer development system—ready for immediate delivery. For short-term or long-term rental. At rates that make sense. We offer the complete range of Intel equipment including the ICE-86 plug-in emulator. Backed by expert technical support from the only rental firm specializing in microcomputer development systems and equipment. With fast, responsive service support only available from the rental experts. For expert off-the-shelf rental of Intel MDS systems, call us today.

(800) 235-5955
(Within California call collect 213-991-1704)

Microcomputer
Rentals
705A Lakefield Road
Westlake Village,
CA 91361

Intel, and ICE-86 are registered trademarks of the Intel Corporation.

CIRCLE NUMBER 118



μC package aims at process control work

ADAC, 70 Tower Office Park, Woburn, MA 01801. (617) 935-6668. $14,000; 6 to 9 wks.

Prosys I, a microcomputer-based industrial control and measurement system, assists the process control engineer with plain English statements, easily recognizable abbreviations and other nomenclature common to the processing industry. A basic package contains a 64-kbyte version of the DEC LSI-11/2 microcomputer, double-density floppy disk, CRT display with keyboard, a dual-channel serial I/O card and a high-level language software package. Hardware is integrated in a 23-1/2 × 30 × 33-in. cabinet. The system accommodates up to 18 optional I/O modules.

CIRCLE NO. 346

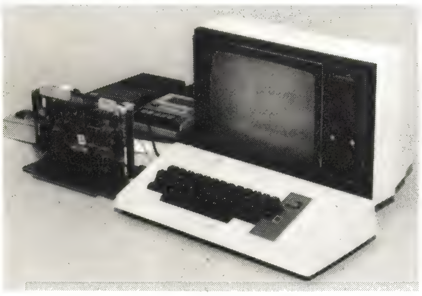
CP/M system opens desktop μC options

Pertec Computer, 12910 Culver Blvd., Los Angeles, CA 90066. (213) 822-9222.

CP/M, Digital Research's proprietary operating system, enhances the capabilities of the PCC 2000 desktop computer system. With CP/M, the computer can run applications programs written in Microsoft's Basic-80, Fortran-80 and Cobol-80. Basic facilities of CP/M include dynamic file management, a fast assembler, a general-purpose text editor, an advanced debugger and several utilities.

CIRCLE NO. 347

Complete system develops 6500 series μPs

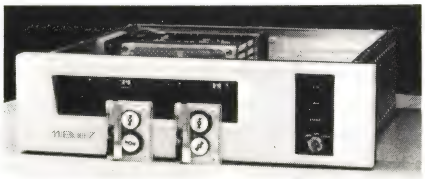


Synertek, 3001 Stender Way, Santa Clara, CA 95051. (408) 988-5600. $1495.

A microprocessor development system, MDT 1000, allows users of 6500 series microprocessors to write programs and debug both hardware and software. The system includes a 54-key keyboard and case, a 12-in. video monitor, a dual cassette interface, a power supply, an EPROM programmer, a 4-kbyte static RAM board, a CPU board with serial and parallel printer interfaces, a video interface, sockets for four ROMs, system RAM and ACIA for serial communications and a four-slot motherboard with two sockets installed. Software support includes 12-kbytes of ROM-resident firmware, a 4-k monitor with debug and an 8-kbyte assembler/editor which operates on line-numbered text. System hardware is compatible with Motorola's EXORciser bus to facilitate easy expansion.

CIRCLE NO. 348

LSI-11 based system stores on-site data

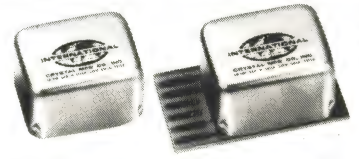


Transduction, 14761-A Franklin Ave., Tustin, CA 92680. (714) 838-4742. $2900 (with tape drive); stock.

An LSI-11 based computer system, with built-in tape cassette storage capability, provides remote data acquisition and communications where local storage is important. Self-contained in a 5.25-in. high rack-mountable enclosure, 11/BLUE7 offers up to 512-k sequential storage on its optional DEC Model TU58-BB dual-drive unit. Included in the system are an 8-slot LSI-11 backplane, a power supply and a keylock-controlled panel.

CIRCLE NO. 349

INTERNATIONAL
OE CRYSTAL OSCILLATOR ELEMENTS



International's OE Series of Crystal Oscillator Elements provide a complete crystal controlled signal source. The OE units cover the range 2000 KHz to 160 MHz. The standard OE unit is designed to mount direct on a printed circuit board. Also available is printed circuit board plug-in type.

The various OE units are divided into groups by frequency and by temperature stability. Models OE-20 and OE-30 are temperature compensated units. The listed "Overall Accuracy" includes room temperature or 25°C tolerance and may be considered a maximum value rather than nominal.

All OE units are designed for 9.5 to 15 volts dc operation. The OE-20 and OE-30 require a regulated source to maintain the listed tolerance with input supply less than 12 vdc.

Prices listed include oscillator and crystal. For the plug-im type add the suffix "P" after the OE number; eg OE-1P.

OE-1, 5 and 10 can be supplied to operate at 5 vdc with reduced rf output. Specify 5 vdc. when ordering.

Output — 10 dbm min. All oscillators over 66 MHz do not have frequency adjust trimmers.

Catalog	Oscillator Element Type	2000 KHz to 66 MHz	67 MHz to 139 MHz	140 MHz to 160 MHz	Overall Accuracy	25°C Tolerance
035213	OE-1	$15.66			±.01% −30° to +60°C	±.005%
035214	OE-1		$17.99			
035215	OE-1			$22.63		
035216	OE-5	$19.44			±.002% −10° to +60°C	±.0005% 2 −66MHz ±.001% 67 to 139 MHz ±.0025% 140 to 160 MHz
035217	OE-5		$22.91			
035218	OE-5			$30.17		

Catalog Number	Oscillator Element Type	4000 KHz to 20000 KHz	Overall Accuracy	25°C Tolerance
035219	OE-10	$22.91	±.0005% −10° to +60°C	Zero trimmer
035220	OE-20	$33.65	±.0005% −30° to +60°C	Zero trimmer
035221	OE-30	$69.63	±.0002% −30° to +60°C	Zero trimmer

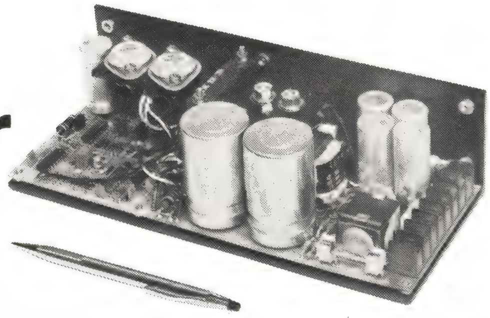
ICM

INTERNATIONAL CRYSTAL MFG. CO., INC.

10 North Lee
Oklahoma City, OK 73102
405/236-3741

CIRCLE NUMBER 60

The Power Saver®



Power Dynamics offers the first in a series of open-frame switching power supplies for the OEM user. Unencumbered by past ideas and methods, Power Dynamics offers advanced technology and conservative design to meet today's need for higher efficiencies and reliability.

The Model PD100 is a convection-cooled 20 amp supply with a user specified output of 2 to 48 VDC.

Features Include:
- Dual Range 115/230 VAC Strappable Inputs
- Undegraded Performance to 50°C
- 30 msec Holdup Time
- No Overshoot on Turn-On or Turn-Off
- Fully Protected Output
- Designed to Meet UL 478
- Two Year Warranty

The Model PD100 is in stock. Call us for your application:
(213) 767-9640, 875-1012 • TWX: 910-498-4841

POWER DYNAMICS CORP.
9421 Telfair Avenue, Sun Valley, CA 91352

CIRCLE NUMBER 61

Controller offers the right touch for fast test and measurement

John Fluke Manufacturing Co., P.O. Box 43210, Mountlake Terrace, WA 98043. (800) 426-0361. Fall, 1980.

An instrument controller, Fluke's 1720A, uses touch-sensitive CRT data entry to streamline man-machine interfacing and speed accurate testing and measurement. Only valid choices are presented to the user; the correct choice is selected when touched.

Tutorial messages on the display screen simplify operation for inexperienced users. A programmer can tailor a test program to match the skills of the operator.

Interface circuits to instruments and equipment follow IEEE-488-1978. Up to 28 devices, on two independent buses, can be controlled as part of the same system. Programming language is enhanced Basic.

For program development, a keyboard includes a full set of ASCII character and control keys. Blink, intensify and individual character editing are standard. Page format or full scroll, as well as double-size characters, make viewing easy.

Standard read/write memory stores 30,000 18-bit words, with ample room provided for system software and typical application programs. Internal bulk memory emulates a fixed-head 256-kbyte "electronic disk."

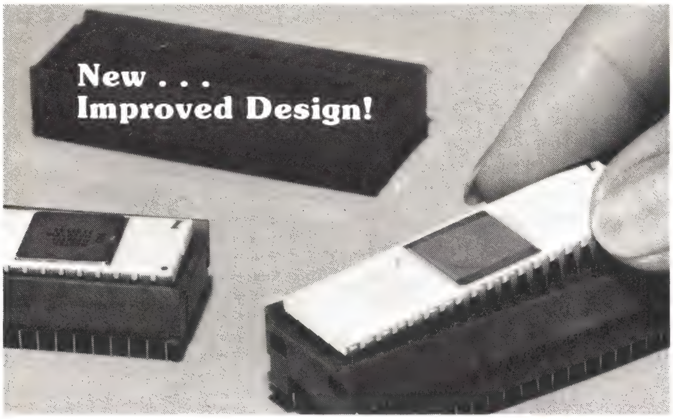
CIRCLE NO. 309

Hand-held tool calibrates process instruments

Promac Controls, 30 Progress Ave., Scarborough, ONT M1P 2Y2. (416) 292-1444.

A hand-held, microprocessor-based instrument, Model DHT 720, quickly calibrates process controllers, transmitters, transducers and recorders. The unit measures and generates milliampere, millivolt and voltage ranges. A 4-1/2 digit LCD readout indicates input and output measurements. Accuracy is better than 0.05% on all ranges. The instrument measures 8-1/2 × 4-1/2 × 4 in. and comes with a carrying case, test leads and a line cord.

CIRCLE NO. 385



Costly I/Cs Need Our "Zero-Insertion-Force" Production Sockets!

- Improved socket opens easily, retains device with 50% greater force than original design!
- No tools — or screwdrivers — necessary for opening or closing socket.
- I/Cs literally "drop" into open socket — no lead damage!
- Positive-wiping, dual-leaf contacts provide true reliability when socket is closed.
- New design now available for 24- and 40-lead production applications.

Welcon™

"See Our Full Line at Nepcon West Booth No. 314."

WELLS ELECTRONICS, INC., 1701 S. Main, So. Bend, IN, USA

CIRCLE NUMBER 62

HERMETICALLY SEALED

SWITCHES

-320°F to +660°F

- *Is extreme high or low temperature a problem?*
- *Trouble with vibration or high shock?*

HSI Hermetically Sealed Switches developed for supersonic aircraft and missile use provide the answer to many of your environmental problems. You can use these switches at temperatures up to +660°F or down to −320°F, in corrosive atmospheres, under pressure or in a vacuum, where you can't tolerate arcing, or where you have shock or vibration problems.

Where performance requirements dictate, an entirely special switch assembly can be designed.

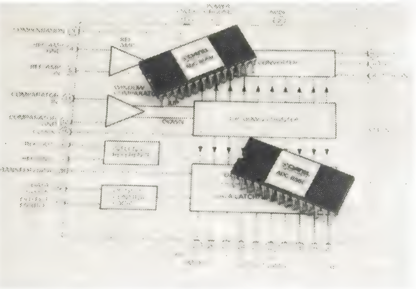
Our engineers would like to talk to you concerning your application.

H·S·I® HAYDON SWITCH & INSTRUMENT, INC.
1500 Meriden Road, Waterbury, Conn. 06705
Area Code (203) 756-7441 TWX 710-477-2580

FOR INFORMATION ONLY CIRCLE NUMBER 63
HAVE REPRESENTATIVE CALL CIRCLE NUMBER 111

Analog Circuits

A/d converter updates without sample and hold



Datel-Intersil, 11 Cabot Blvd., Mansfield, MA 02048. (617) 828-8000. $52 (ADC-856C); $83 (ADC-856M); stock to 4 wks.

A 10-bit tracking a/d converter, ADC-856, supplies continuously updated conversion data on full-scale sinusoidal signals up to 300 Hz without need for a sample-and-hold. The bipolar, monolithic device contains a fast window comparator, tracking logic, an up/down counter, a d/a converter, a precision voltage reference with amplifier, data transfer gates and a data latch/shift register. A few passive components allow external programming of the analog input voltage range. The converter is linear to ±1/2 LSB minimum and is monotonic over its operating temperature range. Gain tempco is ±10 ppm/°C, exclusive of reference. ADC-856C operates over a 0 to 70-C range. A military version, ADC-856M, operates from −55 to +125 C. Power need is ±5 V dc at 50 mA. The chip comes in a 28-pin ceramic DIP.

CIRCLE NO. 354

F/v converters stay linear regardless of waveshape

Teledyne Philbrick, Allied Dr. at Rt. 128, Dedham, MA 02026. (617) 329-1600. P&A: See text.

Hybrid f/v converters, 4732 and 4734, provide an output voltage whose magnitude is linearly proportional to the input frequency, regardless of waveshape. Model 4732 is a 10 Hz to 11-kHz unit with a typical nonlinearity of ±0.001% full scale. Tempco is ±15 ppm/°C typical. Model 4734 covers 100 Hz to 110 kHz with a typical nonlinearity of ±0.002% and a tempco of ±15 ppm/°C typical. The devices serve a wide variety of purposes, including measurement of flow, revolutions and frequency. Used with counterpart v/f converters, the units form the basis of a high-performance fiber optic data link or magnetic tape recording system. Model 4732 costs $106; Model 4734, $115, both in quantities of 100. Military versions are $141 and $149, respectively. All units are available from stock.

CIRCLE NO. 355

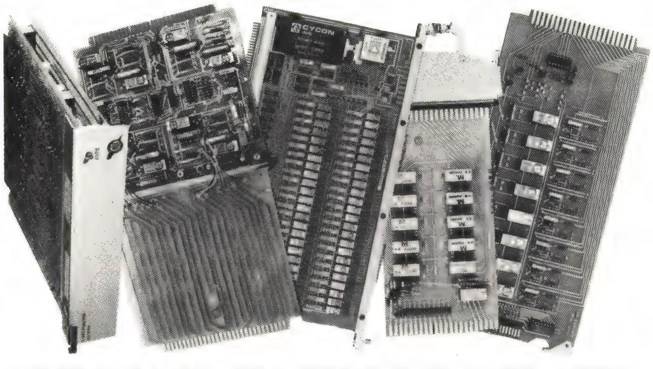
Analog multiplexers work fast in data acquisition

Harris Semiconductor, P.O. Box 883, Melbourne, FL 32901. (305) 724-7000. $13.85 to $69.13 (25 qty).

Two high-speed analog multiplexers, HI-516 (16 channel) and HI-518 (8 channel), improve system speed in data acquisition systems. The monolithic CMOS devices offer a typical access time of 90 ns and a typical settling time of 800 ns to 0.01%. Substrate leakages and parasitic capacitances are low. Either unit operates in a single-ended or differential mode. HI-516 comes in a 28-pin ceramic DIP; HI-518, an 18-pin ceramic DIP.

CIRCLE NO. 356

WHAT'S BEST FOR LOW-LEVEL SIGNAL SWITCHING?



THERMOSEN TYPE D RELAYS.

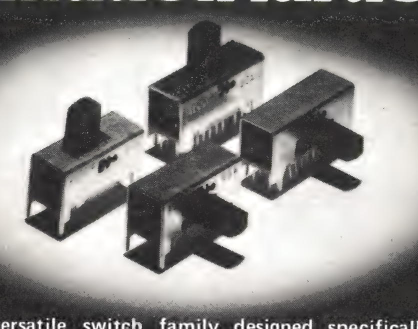
Our unique Type D relays are specifically designed to provide optimum performance in critical low-level switching applications. Useful in data acquisition systems, test instruments, and automatic testing equipment, they offer the advantages of low thermal emf, low dynamic noise, low stable contact resistance, high speed, long life/high reliability, excellent high frequency performance, very high insulation resistance, and true Form C switching. Maybe that's why they're specified so frequently to solve those really tough industrial, laboratory, and marine switching problems.

We've delivered hundreds of thousands of these Type D relays over the years. Why not let us tell you all about them? Write for our updated bulletin TR-4 today. We're Thermosen, Inc., 375 Fairfield Avenue, Stamford, CT 06904, (203) 324-6125.

MULTI REED THERMOSEN

CIRCLE NUMBER 64

Slide Switches for industrial use.



A most versatile switch family designed specifically for printed circuit applications. Our outstanding design feature is a unique wiping action, using a bifurcated contact to assure a low contact resistance.
These we call our MSSA Series.

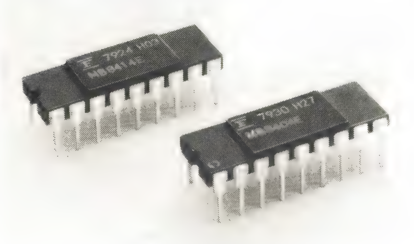
- 1,2,3 or 4 POLE, DOUBLE THROW OPTION
- CHOICE OF 3 or 4 POSITIONS
- UPRIGHT or RIGHT ANGLE MOUNTING
- PC LEVELLING TABS ADD STABILITY
- EPOXY SEALED TERMINALS (optional)
- HIGH QUALITY AT ECONOMY PRICES
- CHOICE OF: GOLD or SILVER PLATED CONTACTS and TERMINALS

ALCOSWITCH®

ALCO ELECTRONIC PRODUCTS, INC. a subsidiary of Augat®
1551 Osgood St., No. Andover, MA. 01845 USA
Tel: (617) 685-4371 TWX: 710 342-0552

CIRCLE NUMBER 65

CMOS static RAMs retain 4-k and draw low power

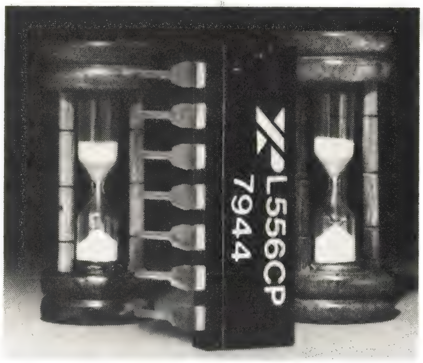


Fujitsu Microelectronics, 2945 Oakmead Village Ct., Santa Clara, CA 95051. (408) 727-1700.

Two CMOS static RAMs, MB8404E (4096 × 1) and MB8414E (1024 × 4), draw only 275-μW maximum standby power. Operating power dissipation is 17 mW/MHz maximum. The devices feature an address access time of 250 ns maximum. Both devices come in 18-pin DIPs. MB8404E is a plug-in replacement for the industry standard 6504. MB8414E replaces the 6514.

CIRCLE NO. 357

Flea-power dual timer dissipates only 2 mW

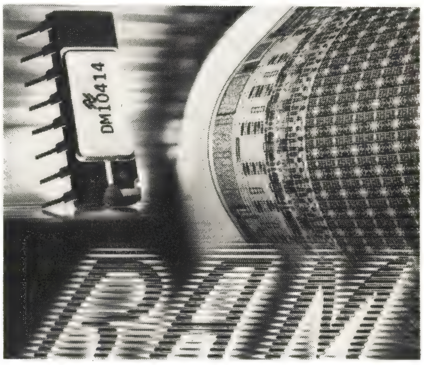


Exar Integrated Systems, 750 Palomar Ave., Sunnyvale, CA 94086. (408) 732-7970. Typical $1.71 (100 qty); stock.

A monolithic, micro-power dual timer IC, XR-L556, dissipates less than 2 mW from a 5-V supply. The circuit, a direct pin-for-pin replacement for the NE-556 dual timer, uses only 1/15th the standby power of conventional devices. Without sacrifice in timing accuracy and stability, the XR-L556 operates on a supply of only 2.5 V. The output is free of switching transients and is CMOS, TTL and DTL compatible. Commercial and military versions are offered.

CIRCLE NO. 358

ECL RAM accesses data in 7 ns typical



National Semiconductor, 2900 Semiconductor Dr., Santa Clara, CA 95051. (408) 737-5000. $10.65 (100 qty); stock.

First in a family of ECL RAMs, the DM10414 stores 256 bits and accesses data in just 7 ns typical. Typical chip select access time is 3 ns. The device is organized in a 256 × 1 bit format. An unterminated emitter follower output allows wired-OR interconnects required for multiple RAM arrays. The output uses a 50-Ω resistor to a 2-V supply to provide a low at the output when the device is off. Separate data-in and noninverted data-out pins are provided. A −5 V supply is required.

CIRCLE NO. 359

POCKET ASCII TERMINAL

MIDGET DUPLEX UNIT WITH MAN-SIZED CAPABILITIES

Here's $395 worth of convenience for anyone working with digital systems. Carry it anywhere in a pocket, valise or toolkit to enter and retrieve data, run diagnostics, change constants, test data links, etc.

Look at its facilities:
- Transmits 128 ASCII codes
- Can display last 30 characters received
- Displays full 64-character ASCII set on clear 16-segment LEDs
- 25-line RS232/c compatible interface
- Single 5V supply required at 400mA typical
- 110 or 300 baud transmission selectable
- Parity codes, stop bits settable to your standard
- Obeys bell, cursor and data format control codes

Phone or write us for more details now:

GR ELECTRONICS,
1640 Fifth Street,
Santa Monica, CA 90401.
Telephone: (213) 395-4774.
Telex: 65-2337 (BT Smedley SNM).

CIRCLE NUMBER 55

The fun's already there... this guide puts the *profit* into personal computers!

HOW TO PROFIT FROM YOUR PERSONAL COMPUTER: Professional, Business, and Home Applications

by T. G. Lewis

For every small business owner and professional, this guide describes the many business uses of personal computers and gives actual BASIC language programs for such diverse uses as: accounting, handling payrolls, managing inventory, and sorting mailing lists. It is written in an entertaining style with many anecdotes and tales of success.

#5761-X, paper, 208 pp., $9.65

Write to: **HAYDEN BOOK COMPANY, INC.**
50 Essex Street, Rochelle Park, NJ 07662

When sending payment with order, residents of NJ and CA must add sales tax. Price is subject to change without notice.

CIRCLE NUMBER 54

Save up to 30% in energy costs.

Free booklet explains how to manage energy to save money.

The big challenge facing every American company today is how to make the most of the energy we have.

The big trick is how to find out exactly how much energy you're using and how much you are spending for it. In short, a complete analysis of your energy use.

The Alliance to Save Energy offers an energy accounting and analysis system developed by The Carborundum Company which spells it out simply and powerfully. It helps you determine how and where your company consumes energy, shows how to measure it against previous consumption, and recommends ways to conserve energy and save money. Using this system, many companies have found ways to save thousands of dollars with little or no capital outlay.

The Alliance to Save Energy will happily send you one or more of these booklets. We want to do all we can to help you help America preserve its precious resources.

Saving energy has its management rewards—not only in the warm feeling you get from contributing to the nation's welfare, but in cold, hard cash.

For example, one car manufacturing company discovered that by changing its type of primer paint (with no loss in quality) it could reduce the bake temperature and drastically cut energy consumption. Cost: $1,800 a year. *Savings: $13,000 a year.*

Real estate management people found that by switching from standard bulbs to low-energy bulbs they lit the way to a savings windfall. Ten year maintenance cost: $10,304. *Ten year pre-tax savings: $50,026.*

The remarkable feature of this energy accounting system is that it can be applied successfully to almost any kind of structure—office building, hospital, hotel, store, factory, refinery. The Department of Commerce has voiced its enthusiasm for this energy-saving system in the halls of Congress.

No matter what business you're in, you're sure to save energy and energy costs through the application of this system.

Send for this booklet today. Fill in the coupon below.

ALLIANCE TO SAVE ENERGY
1925 K Street, N.W., Suite 506, Washington, D.C. 20006

Please send me ____ copy (copies) of The Carborundum System of Energy Accounting and Analysis booklet.

Name ____________________

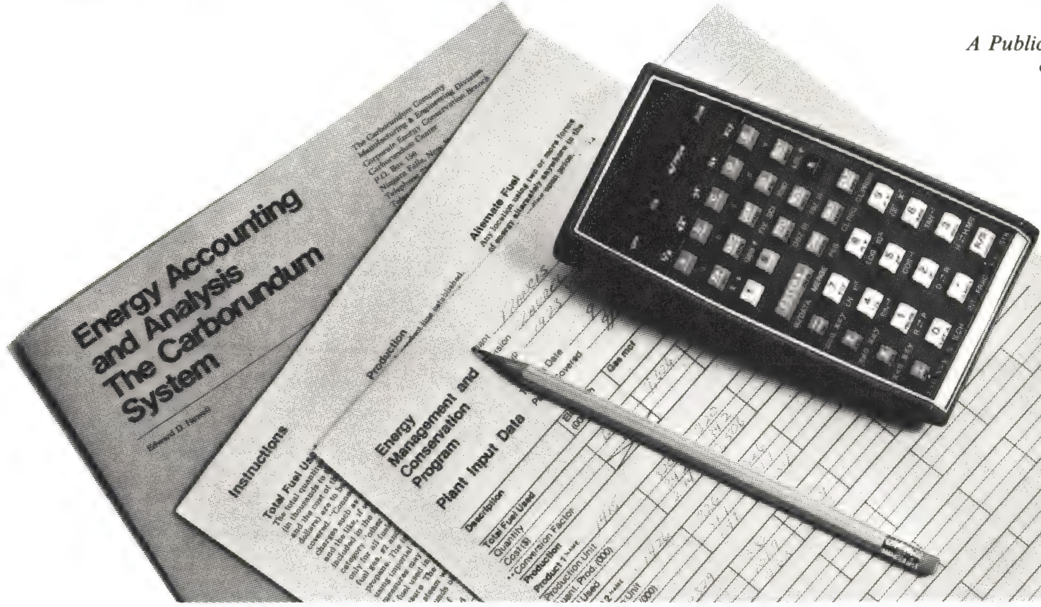
Company Name ____________________

Company Address ____________________

Type of business ____________________

City ________ *State* ________ *Zip* ________

A Public Service of This Magazine
& The Advertising Council


Energy Accounting and Analysis The Carborundum System
Instructions
Energy Management and Conservation Program
Plant Input Data
Production
Alternate Fuel

Why telecom majors

And why more are on the way.

The reasons are impressive. Major manufacturers of digital central office switch equipment have designed the Mostek Codec into their systems because Mostek gives them across the board advantages.

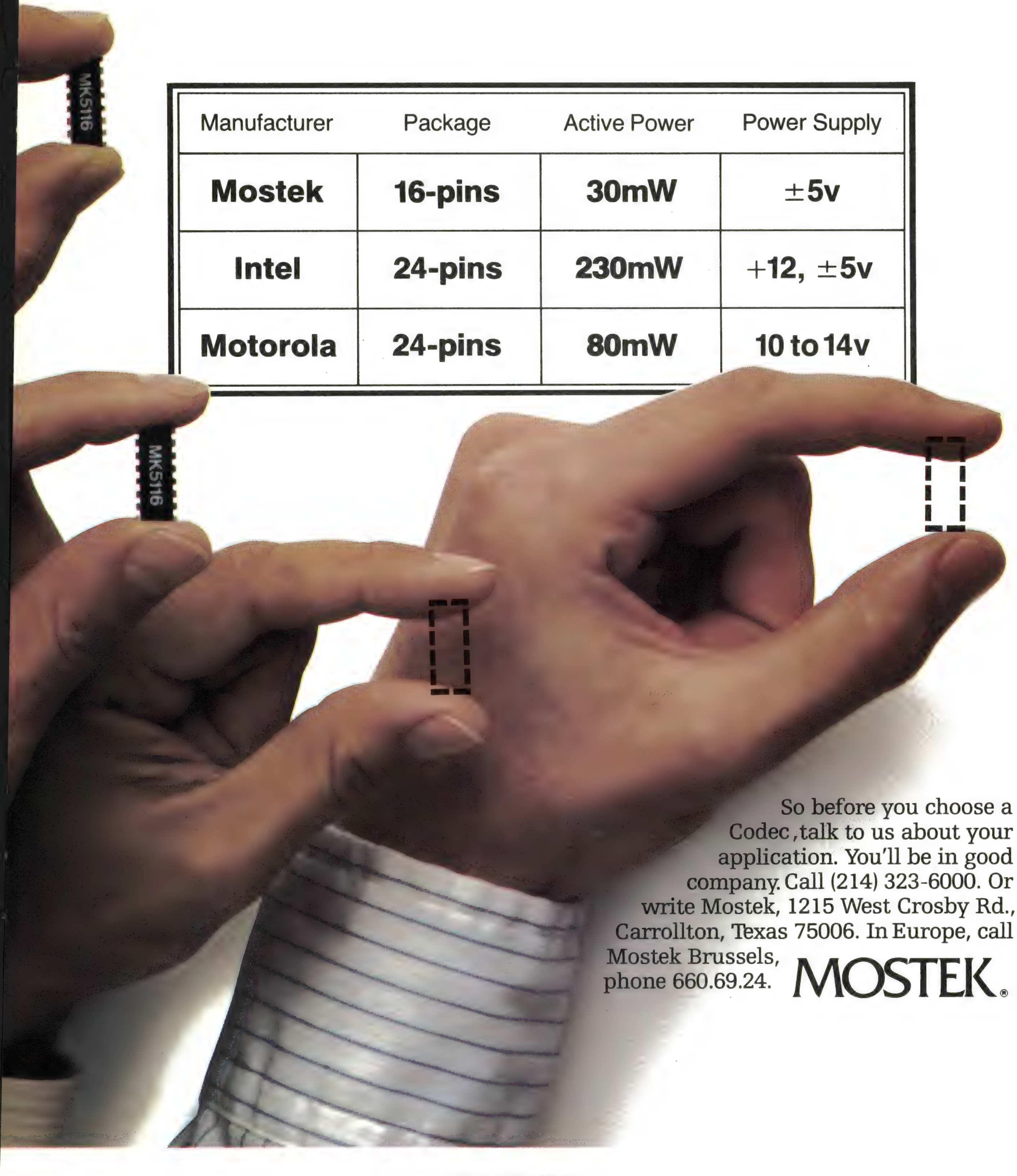
Cost savings: The low, 30mW power dissipation of the small 16-pin package accounts for big system cost savings and improved system reliability.

Quality: The Mostek Codec meets all D3 channel-bank specifications.

Availability: Over 5 years ago, Mostek made a significant commitment to the telecommunications industry. During that time, Mostek has led in the development of circuits for digital switching applications. As proof, two companies have already announced as alternate sources for Mostek Codecs. Equally impressive, in just 5 years, Mostek has shipped over 10 million telecommunications circuits — more than all other manufacturers combined.

©1979 Mostek Corp.

chose Mostek's Codec.



Manufacturer	Package	Active Power	Power Supply
Mostek	**16-pins**	**30mW**	**±5v**
Intel	**24-pins**	**230mW**	**+12, ±5v**
Motorola	**24-pins**	**80mW**	**10 to 14v**

So before you choose a Codec, talk to us about your application. You'll be in good company. Call (214) 323-6000. Or write Mostek, 1215 West Crosby Rd., Carrollton, Texas 75006. In Europe, call Mostek Brussels, phone 660.69.24.

MOSTEK®

CIRCLE NUMBER 65

Design Aids

Springs and wires

Springs, spring ends, retainer rings, clips, special stampings, wire forms and shaped wire are illustrated in a wall chart. Acme/Monaco/Accu-Wire.

CIRCLE NO. 360

Voltage control

Select the correct voltage conditioning product for any application by using an automatic voltage slide rule. Both single and three-phase applications are included. The Superior Electric Co.

CIRCLE NO. 361

Watch/clock circuits

LCD watch and clock circuits are shown on an 18 × 24-in. wall chart. The wall chart outlines each circuit, showing a list of its functions and simulated displays. OKI Semiconductor.

CIRCLE NO. 362

Thermoplastic resins

A combination materials evaluator/injection-molding troubleshooting guide provides a quick and easy way to compare several thermoplastic resins. Remedies are suggested for molding problems. ARCO Polymers.

CIRCLE NO. 363

AQL sampling tables

A pocket-sized card features tables to determine AQL (Acceptable Quality Levels) per MIL-STD-105D; sampling tables (statistical) per MIL-5-19500 and MIL-M-38510 for lot tolerances and maximum percentage defective. Tekform Products.

CIRCLE NO. 364

Data-comm calendar

A 1980 calendar lists the dates of major data-comm trade shows and conferences as well as historical events relating to communications. Racal-Milgo.

CIRCLE NO. 365

Evaluation Samples

Amine curatives

An aromatic diamine curative for epoxies and urethanes features excellent physical and electrical properties, good heat stability and handling characteristics, as well as chemical resistance. Uniroyal Chemical Customer Service.

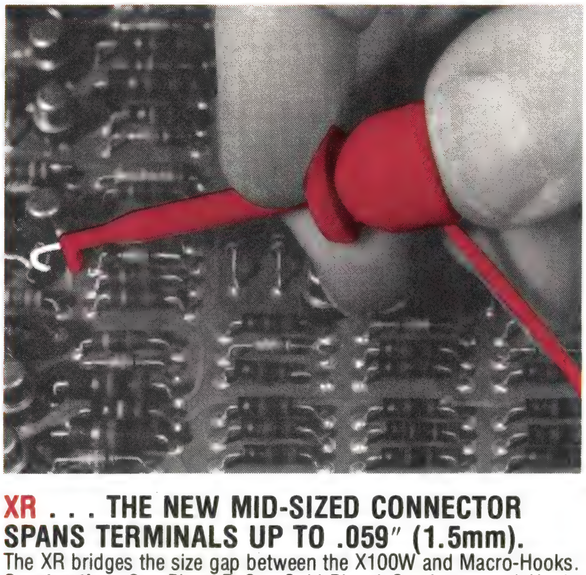
CIRCLE NO. 366

Stainless-steel cables

Miniature stainless-steel cables ranging in size from 0.006 to 0.046-in. dia. are available either bare or nylon coated. An accompanying catalog contains a five-step system design guide and an easy-to-read performance chart. Cable Manufacturing & Assembly Co.

CIRCLE NO. 367

E-Z-HOOK®
PROBLEM SOLVER NO. 3



XR . . . THE NEW MID-SIZED CONNECTOR SPANS TERMINALS UP TO .059" (1.5mm).
The XR bridges the size gap between the X100W and Macro-Hooks. **Construction:** One-Piece BeCu, Gold-Plated Conductor and Hook. Heat and Chemical Resistant Nylon Body. Stainless Steel Spring. **Colors:** Blk, Brwn, Red, Orng, Yello, Green, Blue, Violet, Gray, White. **Model XR25** has .025" (.635mm) square post built into plunger to snap onto square push-on type connectors. Increases flexibility.

SEND FOR COMPLETE CATALOG AND PRICE LIST

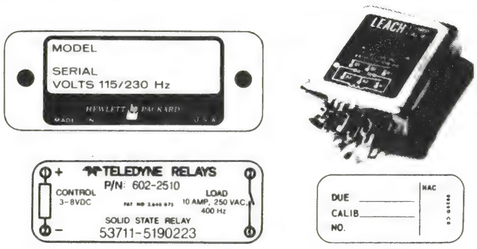
E-Z-HOOK®
A DIVISION OF TEKTEST, INC.

MAILING ADDRESS: P.O. BOX 450
ARCADIA, CALIFORNIA 91006
(213) 446-6175 / TWX 910 582 1614

CIRCLE NUMBER 68

You Deserve Quality In
LABELS
DECALS & ANODIZED
NAMEPLATES

For 25 years Steven Label Corporation has given your product the best in identifying quality, the quality it deserves.



ALL PHASES OF PRESSURE SENSITIVE NEEDS
Product identification, calibration labels, inventory control labels terminal identification, custom EDP labels, nameplates

STEVEN

Call or write for information on any pressure sensitive needs.

SLC STEVEN LABEL CORP.
P.O. Box 3688, 11926 Burke Street, Santa Fe Springs, CA 90670 (213) 698-9971, (714) 521-2045, Toll free in California (800) 352-4330 Outside of California call (800) 423-4709

STICK WITH STEVEN

CIRCLE NUMBER 69

New Literature

Peripheral equipment

A supply network of computer peripheral equipment is described in a 12-page catalog. Manufacturers inventoried include Anderson Jacobson, DEC, Diablo, GE, Hazeltine, HP, Lear Siegler, NEC, Spectron, Tektronix, Teletype and Texas Instruments. Leasametric, Foster City, CA

CIRCLE NO. 368

Transient recorders

The performance of nine transient digitizers are summarized in a catalog. The relationship of associated IC memory modules, programmable amplifiers, a clock generator and computer interfaces are explained. A specification summary chart is included. LeCroy Research Systems of California, Palo Alto, CA

CIRCLE NO. 369

Opto-electronic devices

A 14-page guide for opto-electronic replacement products cross-references 1000 industry part numbers to 117 Sylvania ECG devices. Sylvania Electronic Components Group, Williamsport, PA

CIRCLE NO. 370

Bipolar digital ICs

An eight-page guide covers radiation-hardened dielectric-isolated (DI) digital circuits. Examples of this technology, such as DI PROMs and DI RAMs, are given. Harris Semiconductor, Programs Div., Melbourne, FL

CIRCLE NO. 371

Clad-metal systems

An illustrated, loose-leaf brochure describes precious and base metal clad materials for electrical and electronics applications. American Clad Metals, Pawtucket, RI

CIRCLE NO. 372

Transistors

A series of "Quick Reference Guides" to the firm's transistor products is organized by applications. The guides cover military wideband balanced, microwave, military, linear, land mobile and TACAN/DME/IFF transistors. Communications Transistor, San Carlos, CA

CIRCLE NO. 373

Converters

A pocket-sized guide, *Up-Front Facts About Data Converter Selection,* helps designers choose the optimum converter, by eliminating the common problems of overspecifying and underspecifying. Definitions of specifications, state-of-the-art advances and performance trade-offs are included. ILC Data Device, Bohemia, NY

CIRCLE NO. 374

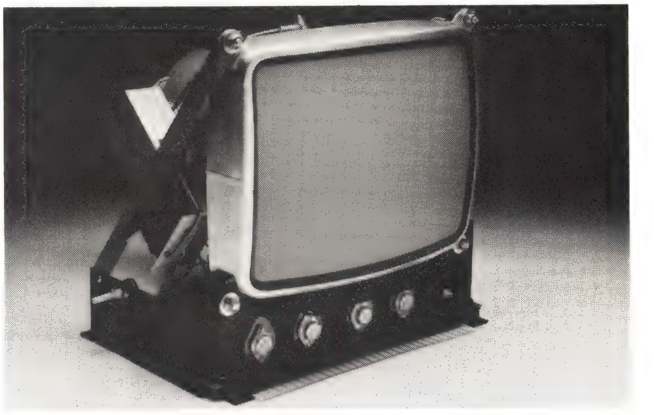
DIRECTORY BLUES?

Chase them with GOLD BOOK. Some directories promise more than they deliver. You don't find the products you're seeking. You can't locate the manufacturer's address you need. Distributor directories have been eliminated. But check ELECTRONIC DESIGN's GOLD BOOK. Here you'll find the World's Most Complete Electronics Directory. Every effort has been made by the GOLD BOOK editorial staff to publish a listing on every known electronic component, sub-system, and system — and their manufacturers. Over 10,000 US and non-US manufacturers are listed, many with complete sales outlet listings (sales offices, reps and distributors). Two distributor directories (one alpha, one geo) and a trade name directory complete the editorial file. Specs on thousands of products provided by hundreds of manufacturers complement the editorial listings. Every time you need a directory — reach for GOLD BOOK. It's a sure cure for the blues.

"Over 108,000 Distributed Worldwide."

Electronic Design's
GOLD BOOK
THE WORLD'S MOST COMPLETE ELECTRONICS DIRECTORY

Hayden Publishing Company Inc.
50 Essex St., Rochelle Park, NJ 07662 • 201-843-0550



No Frills Color. Just the basics. If you're a black and white terminal manufacturer, the Intecolor 813 is all you need to upgrade your terminals to color.

It consists of an 8-color, 13" CRT, plus a special Analog Module System with all the circuitry necessary to perform deflection and video drive functions for the CRT. The completely self-contained circuitry is on a single printed wiring board which also generates the low voltage, high voltage and CRT bias, mounted on a sturdy aluminum frame for heat sinking the power transistors needed for the circuitry.

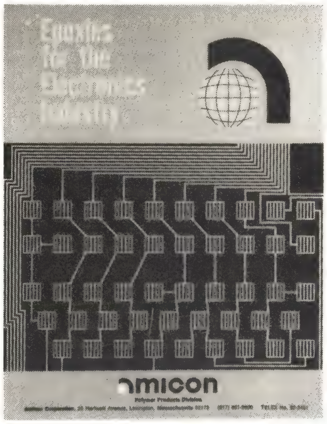
With our Nine Sector Convergence System, perfect color registration takes only three to five minutes. And this convenient control panel can be located anywhere for easy access.

Available in standard 262 Raster line or 400 Raster line high scan versions. If you're ready to upgrade to a color line, call 404/449-5961 for a demonstration.

Color Communicates Better
Intelligent Systems Corp.®
Intecolor Drive • Technology Park/Atlanta • Norcross, Ga. 30092
Telephone 404/449-5961 • TWX: 810-766-1581

CIRCLE NUMBER 70

(continued from page 127)



Epoxies

Conductive and insulating adhesives and coatings created for electronic/microelectronic applications are featured in a catalog. Amicon, Lexington, MA

CIRCLE NO. 375

Meters

Commercial-grade OEM meters are featured in a brochure. Custom options, including special dials, tolerances and ranges, are included. Jewell Electrical Instruments, Manchester, NH

CIRCLE NO. 376

Wiring accessories

Mounting accessories, harness-board accessories and cable-tie installation tools are described in a 28-page bulletin. Material specifications, dimensional drawings and packaging information are included. Panduit, Tinley Park, IL

CIRCLE NO. 377

Memory test system

Capabilities of the Macrodata MD-207/11 memory test system for boards and systems are highlighted in a 12-page catalog. Application, production and engineering data are included. Eaton, Semiconductor Test Systems Div., Woodland Hills, CA

CIRCLE NO. 378

Temperature measurements

Over 9000 products are shown in the 320-page temperature measurement handbook and catalog. The handbook contains reference tables for thermocouples, material characteristics, conversion charts and thermometry fixed points. Omega Engineering, Stamford, CT

CIRCLE NO. 379

Equipment shielding

Computer equipment shielding techniques are covered in a six-page bulletin. Included are photos, diagrams and drawings. Metex, Electronic Shielding Group, Edison, NJ

CIRCLE NO. 380

Rf ceramic capacitors

A four-page brochure describes titanate capacitors. Application data, including electrical and mechanical considerations, are included. ITT Jennings, San Jose, CA

CIRCLE NO. 381

Cut-cores

A 262-page guide describes more than 2500 standard cut-cores for electronic transformers. Magnetic Metals, Camden, NJ

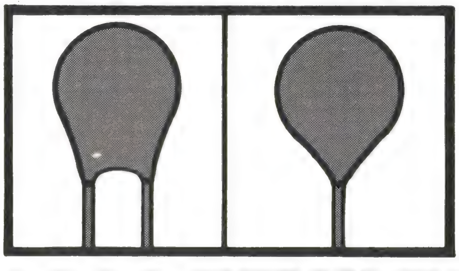
CIRCLE NO. 382

Matrix boards

Detailed information on matrix boards and their applications are provided in a catalog. Sealectro, Mamaroneck, NY

CIRCLE NO. 383

CAPACITOR WANTED



$1,000 REWARD

Dipped-coated, radial-leaded, solid tantalum capacitor with a cross-weld positive lead that can be authenticated as being received from a manufacturer, or distributor, before April 25, 1964.

This capacitor can be a sales sample, purchased product, part of a circuit board or any electric device of which the date of manufacture can be proven.

Only the first five authenticated capacitors, as determined by postmark, will receive the $1,000 reward! We will not assume responsibility for loss or damage of anything submitted.

To make arrangements to have any article you have inspected, please write or call:

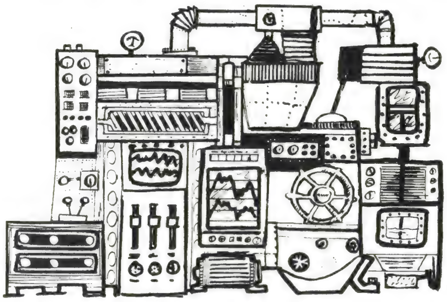
GERMANY
Horst Moser
Wasserburger Landstrasse 268
8000 München 82
Germany
Telefon: (089) 430 2037

UNITED KINGDOM
Erric Nelson
Hilton Road
Aycliffe Industrial Estates
Nr. Darlington, County Durham
England
Telephone: AYCLIFFE 5181

U.S.A.
Lee Shely
Post Office Box 5928
Greenville, SC 29606
Phone: (803) 963-6712
(Call collect)

CIRCLE NUMBER 71

If It's Not in GOLD BOOK...



IT PROBABLY HASN'T BEEN INVENTED YET

When you look in the "World's Most Complete Electronics Directory" you can be confident that the product/service you are seeking will be listed there. Our editorial staff takes pride in presenting the new, the unusual—and the mundane, and in leading you to the product/service you **must** locate to enable you to do your job.

"Over 108,000 Distributed Worldwide"

Electronic Design's
GOLD BOOK
THE WORLD'S MOST COMPLETE ELECTRONICS DIRECTORY

Hayden Publishing Company Inc.
50 Essex St., Rochelle Park, NJ 07662 • 201-843-0550

Umbrella society to be spokesman for engineering

The American Association of Engineering Societies, described as "a single organization to represent the engineering community" by its founders, officially opened for business January 3, 1980. An umbrella organization, it has been set up to be apolitical and nonprofit (C3-type organization)—basically, an advisory and communications service for preparing white papers and conducting forums "to advance the science and practice of engineering in the public interest."

AAES completely replaces the now defunct Engineers Joint Council, whose effectiveness was limited because the country's two largest engineering societies—the Institute of Electrical and Electronic Engineers and the National Society of Professional Engineers—were not dues-paying members. AAES has also taken over the college-accreditation functions formerly performed by the Engineers Council for Professional Development. Apparently, it will not be a substitute for the professional-activities programs currently undertaken by IEEE, NSPE and others.

AAES' appeal to IEEE and NSPE centers on provisions in its constitution that allow *ad hoc* participation in various programs or committees, according to Joe Alford, executive director of the American Institute of Mining, Metallurgical and Petroleum Engineers, who has been actively involved in setting up the umbrella organization. This means that member societies retain some direct control over how their dues money is allocated among AAES activities, no matter how popular—or unpopular—those programs may be.

Voting strength is apportioned according to the size of each member society. More important, however, votes can be split if a particular member society is not unanimously behind a particular AAES proposal. This will prevent simple majority opinion (on a society-by-society basis) from turning into landslide endorsements (or condemnations) when projects are under first consideration.

AAES will be spending approximately $1.5-million during 1980. Dues to cover these expenses will be collected from all affiliated societies at a rate of 65¢ per individual U.S. member. IEEE, with approximately 152,000 members in this category, will be contributing $99,000. While Institute activists have expressed concern that this money would come out of the U.S. Activities Board budget, IEEE spokesmen say the money will come from general operations funding, and that no dues increase or special assessment will be levied on the U.S. membership.

Job hunting? CESOR wants your resume

With the cooperation of the U.S. Department of Labor, the Council of Engineers and Scientists Organizations has set up a computerized registry of domestic engineers looking for work or interested in changing jobs within the profession. Known as CESOR, and operating since July, 1978, the registry is an effort to assure that qualified and interested domestic engineers are considered for industry jobs before foreigners are recruited.

Coded resume data are filed in a computer made available by the Seattle Professional Engineering Employees Association. When DOL gets an alien certification request, it searches the SPEEA/CESOR computer file for domestic engineers with skills matching those on the request. Individuals thus identified are sent postcards notifying them of a "match" and requesting permission to release their resumes to the company involved. At this point, respondents must indicate interest in temporary employment, permanent employment or both.

The names and resumes of presumably qualified domestic engineers are then supplied to the company seeking alien certification. DOL reviews all rejections of CESOR candidates with a third-party expert. DOL will not issue a temporary work visa (H-2) for a foreigner if a qualified domestic engineer is available for the position.

Success of the CESOR program hinges on widespread, continuing participation by domestic engineers. For more information and an application form with complete instructions, write CESOR, 5019 Barton Place South, Seattle, WA 98118.

Employment index shorn of erratic jumps, drift

Deutsch, Shea & Evans have replaced its Engineer/Scientist Demand Index with a new version, the High Technology Recruitment Index. According to DS&E, the HTRI smooths out the erratic monthly jumps and extreme highs and lows that have characterized the ESDI since its inception in 1961.

Also corrected is a persistent and apparently unwarranted upward drift that developed in the ESDI during the late 1970s, when monthly ESDI figures were regularly exceeding those recorded during 1966, an all-time boom year for engineers. In HTRI computations reworking all the past ESDI data, 1966 clearly retains its record high-demand status.

DS&E still relies on a monthly tabulation of technical recruitment advertising in selected newspapers and trade journals as its source of raw data. These figures are seasonally adjusted and massaged by computer according to a process developed by Derek de Solla Price, Avalon Professor of History, Yale University. Now, however, the "column inches" of space these ads take up is not a factor; just the sheer number of ads. Also, the announced "monthly" HTRI figures are no longer independent computations, but running averages spanning three months. This averaging removes many erratic jumps that might otherwise be mistaken for trends.

For example, the HTRI index for October, 1979, was 141 (relative to the base year 1961, arbitrarily demand-ranked at 100). The October figure is actually the average of data gathered in September, October and November. Likewise, the November 1979 figure will be based on data for October, November and December.

Don Mennie

Electronic Design

recruitment and classified ads

PLACE YOUR AD AT ONLY $60 PER COLUMN INCH IN

Electronic Design

YOU REACH ENGINEERS WITH TITLES LIKE THESE:

• Chief Engineer • Development Engineer • Design Engineer • Project Engineer • Electronic Engineer • Engineer-Supervisor • Section Leader • Staff Engineer • Systems Engineer • Test Engineer • Standards Engineer • Master Engineer

Total Qualified and Paid 112,000

Electronic Design RECRUITMENT ADVERTISING RATES

15% commission to recognized agencies supplying offset film negatives. 2% 10 days, net 30 days. Four column makeup. Column width 1-3/4" x 10"

SPACE	DIMENSIONS Wide	Deep	COST
*One column inch	1-3/4"	x 1"	$65.
1/8 page (1/2 col.)	1-3/4"	x 5"	$322.
1/4 page (1 col.)	1-3/4" 3-1/2"	x 10" Vert. x 5" Hor.	$644.
1/2 page (2 cols.)	3-1/2" 7"	x 10" Vert. x 5" Hor.	$1,287.
3/4 page (3 cols.)	5-1/4"	x 10"	$1,931.
1 page	7"	x 10"	$2,574.

REVISED RECRUITMENT & CLASSIFIED RATES

	1X	4X	7X	13X	19X	26X	39X	52X
*Per Column Inch	$65	$63	$59	$54	$52	$50	$49	$48

LATE CLOSING DATES

Electronic Design is mailed every two weeks. Because of its timeliness, personnel recruitment advertising closes only two weeks before each issue's mailing date.

Issue Date	Closing Date	Mailing Date
February 15	**January 18**	February 1
March 1	**February 1**	February 15
March 15	**February 15**	February 29
March 29	**February 29**	March 14
April 12	**March 14**	March 28
April 26	**March 28**	April 11

HOW TO PLACE YOUR AD

CALL THE RECRUITMENT
HOT LINE 201-843-0550
TELECOPIER EXT. 212

Camera-ready film (right reading negatives, emulsion side down) or camera-ready mechanicals must be received by deadline. Or, if you wish us to set your ad (typesetting is free) simply pick up the phone and call our RECRUITMENT HOT LINE – (201) 843-0550. Ask for:

Roberta Renard
RECRUITMENT ADVERTISING MANAGER
ELECTRONIC DESIGN
50 Essex Street, Rochelle Park, New Jersey 07662

NAVAL RESEARCH LABORATORY SPACE SCIENCE DIVISION

ELECTRONIC ENGINEER POSITION

GS-12 ($24,703 — $32,110 per annum)
Grade and salary dependent on qualifications.

Serves as Project Manager for the development of specialized state-of-the-art rocket and satellite borne instrumentation in the field of Solar Physics Research. Immediate tasks will concentrate on the preparation of solar physics instrumentation to be flown on the Space Shuttle/Spacelab 2 Mission.

Expertise desired in electronics design and project management of personnel, budgets and schedules.

This is a career Civil Service position with all the normal fringe benefits.

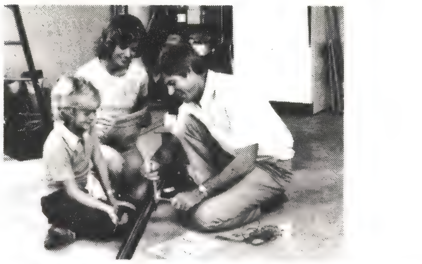
Interested applicants should submit a Standard Form 171, Personal Qualifications Statement or detailed resume by: 29 February 1980 to:

Naval Research Laboratory
Civilian Personnel Office
Attn: Code 71-002-17
4555 Overlook Avenue, S.W.
Washington, D.C. 20375
Telephone: (202) 767-3030

NRL

An Equal Opportunity Employer **U.S. Citizenship required**

STATE OF THE ART TECHNOLOGY, CAREER ORIENTED OPPORTUNITIES, FLORIDA LIVING



Frank Leonard Personnel knows what's important to you.

Yes, the proper experience and capabilities are important, but Frank Leonard Personnel places people, not paper. Our work with people means working with personalities, individual goals, families — all the things your resume can't tell us. We know our client companies very well, now we'd like to know you.

Design Engineers: BSEE/MSEE at least 2 years experience, Digital Design TTL, ECL, CMOS. To work in circuit design, high speed digital modems.

Continuation Engineers: Person to follow new and custom designs from engineering to production. Test digital systems to chip level and solve hardware/software problems.

Test Engineers: Person to work in production test, ATE Design and instrument calibration.

(813) 872-1853
frank leonard personnel
Suite 100-D, 1211 North Westshore Blvd., Tampa, FL 33607

The ground floor opportunities in minicomputers are gone.

Wait a while and you can blow this one, too.

While you weren't looking, several segments of the electronics industry took off without you. And made very successful people out of those who were in on the ground floor.

Although those segments have matured, others haven't even begun to reach their potential. Like Automatic Test Equipment for manufacturing.

We'll tell you the past. And let you predict the future.

Chances are, you know very little about the ATE industry. And even less about GenRad. So here are a few facts to keep in mind.

FACT: The use of PC boards has expanded radically in virtually every industry. New applications come along every day, and as these circuits become more complex, computer-based test equipment is rapidly becoming an economic necessity.

FACT: From 1969 to 1978, the average growth of the ATE board test industry was 25% annually.

FACT: In just the three years from 1975 to 1978, GenRad's sales of PC board test systems grew from $15 million to $42.9 million. A growth of 286%.

FACT: We're still growing. And we need 120 engineers right now to continue.

It takes new technology to stay ahead of the industry.

In an era when everything is becoming computerized, test equipment is no exception. Since 1976, we've introduced no fewer than nine computer-based PC board test systems. And we're planning even more. And as the circuits we test become more sophisticated, our test equipment must become equally sophisticated. To rely on yesterday's technology would put us out of business.

We need 120 engineers to share our growth. Now.

You've heard the words "grow with us" before. From fast growing companies like TI, Digital Equipment Corporation, and National Semiconductor. Now you're hearing it from us, a fast growing company in a growth industry.

We need 120 engineers just to meet today's demands in the ATE market. Good engineers who aren't afraid of responsibility. Or a challenge. Engineers who need to grow. Because that's part of the job.

So think about it. And talk to us. You have nothing to lose by listening. But you may have a lot to lose if you don't.

Software Applications Engineers
Technical Writers
Technical Instructors
Product Service Engineers

If interested in the above positions, please send your resume to Ani Uriarte at our Concord, Mass. address.

Hardware/Software Engineers
Development Engineers
Mechanical Design Engineers
Industrial Engineers
Production Engineers
Component Engineers
New Product Quality Engineers
Quality PCB Specialists
Diagnostic Engineers

If interesed in the above positions, please send your resume to Joan Sawyer at our Concord, Mass. address.

GenRad, Inc., 300 Baker Avenue, Concord, MA 01742.

GenRad

Put our leadership to the test.

An Equal Opportunity Employer M/F.

ENGINEERS: Hardware/Firmware • Software Application • Product Managers

---

Join ALLEN-BRADLEY'S Leaders at the LEADING EDGE of NC/PC Technology

Allen-Bradley Systems Group constantly applies advanced concepts. We progress at the leading edge of technology, not waiting for years to utilize more efficient processors, advanced architecture or more efficient languages. Our Numerical Control and Programmable Controller Systems help increase productivity in all types of industry.

As an important part of an international corporation, employing over 15,000 people, we emphasize a sophisticated professional environment, which promotes your growth and ours.

HARDWARE/FIRMWARE DESIGN ENGINEERS – You're prepared to design and develop numerical control systems and programmable controllers employing advanced digital techniques. B. S. E. E., Scientific or advanced degree with 2+ years experience important.

SOFTWARE ENGINEERS – Advanced concepts provide a variety of exciting opportunities. Capitalize on your Comp. Sci. or related degree and apply your software background at the leading edge.

APPLICATION ENGINEERS – Use your engineering skills to define customer control system requirements, design strategy and prepare proposals, help conduct customer/sales training programs, participate in new product planning and development. Microprocessor and/or programming knowledge a plus.

PRODUCT/MARKETING ENGINEERS – You're B. S. E. E. degreed and have 2+ years background in microprocessor technology. You're capable of participating in research, exploration, identification for product opportunities based on anticipated industry-wide requirements.

These are key technical positions offering outstanding career growth possibilities, excellent compensation and generous benefits.

Grow with us in Northeast Ohio's "Land of the Western Reserve".

Start by sending your resume and current salary history requirements to:

Thomas M. O'Brien Professional Employment
ALLEN-BRADLEY CO.
SYSTEMS GROUP
747 Alpha Drive, Highland Heights, Ohio 44143
Quality in the best tradition.

An Equal Opportunity Employer M/F

Big ads equal big savings

The regular or ROP rate for Electronic Design's full page black and white unit is 23% greater than the *special rate for* recruitment advertising. By using a full page, advertisers get important positioning, frequent domination of the spread — and significant cash savings. Small-space classified display ads are a bargain, too, but nothing can match *full* pages for *full* impact.

A world of opportunity for tomorrow-minded Electronic Engineers at

Martin Marietta Aerospace in Denver

You won't find the challenge greater nor the work more rewarding than at Martin Marietta Aerospace. Overall, we have over 300 contracts including four major product areas each extending into the 1980's. These are the Space Shuttle, Space Launch Systems, Space and Defense Systems, and the new generation mobile Missile X. Additional work in such exciting areas as Command and Information Systems, Space Satellites, Solar Systems, and Payload Integration show why a world of opportunity awaits you at Martin Marietta.

Denver, Colorado

You have to live it, to believe it! Imagine yourself working in a beautiful 5,100 acre setting adjacent to the Rocky Mountains. Your drive to work, which will only be minutes away, is absolutely breathtaking. Towering snowcapped mountains are at your fingertips. Camping, skiing, hunting, fishing, boating, fabulous sightseeing, and a wide variety of recreational activities are at your doorstep. There are educational and cultural facilities that rival any metropolitan area with the advantage of an ideal climate.

Instrumentation Engineers

Requires BSEE with experience with a variety of transducers including strain gauges, accelerometers, position, acoustic, vibration, pressure and temperature instrumentation, process transducer signals, analog signal, conditioning, high rate digitizing, and high speed recording techniques. Specific tasks will include Instrumentation Subsystem design, requirements definition, interface definition, and vendor coordination. Commercial instrumentation experience is acceptable.

Ground Digital Systems Engineers

Requires BSEE and 5 plus years experience in ground digital equipment and test operations. Specific tasks will include system architecture design, requirements definition, test planning analysis and interface definition. Systems will involve computers and associated peripheral equipment including displays, control consoles, RF equipment and power equipment.

Power Systems Engineers

Requires BSEE or MSEE. Five to ten years experience or equivalent in the design of power systems including the use of solar arrays, secondary batteries and complex distribution and power conditioning hardware. Good background in power management and power systems analysis is desirable.

Power Distribution and Cabling Engineers

Requires experience in both electrical and schematic drafting as well as equipment and wire harness installation.

Power Conditioning Design Engineers

BSEE or MSEE required. At least 5 years experience in the design of power supplies, battery chargers and regulators also required.

High Voltage Power Supply Design Engineers

BSEE or MSEE required. Experienced in the design of power supplies ranging from 2KV to 30KV with both low and high power outputs.

Photovoltaics

BSEE or MSEE required. At least 5 years experience in Photovoltaic related areas also required.

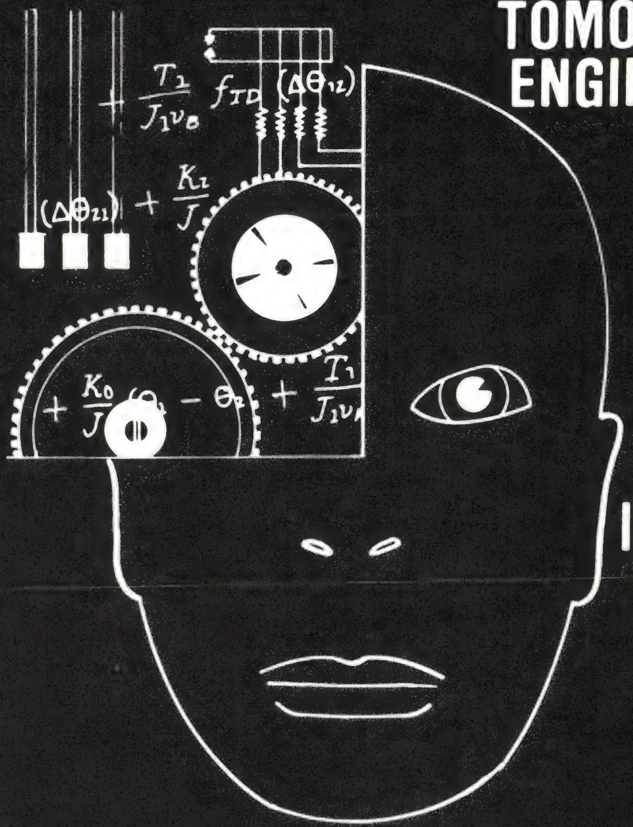
Martin Marietta offers an excellent employee benefit program which includes a performance sharing plan, comprehensive dental plan, tuition refund programs, recreation programs, a job placement assistance for spouses of applicants, and a liberal relocation package which includes pay up to 30 days after arrival per diem, a house hunting trip for employee and spouse, and a return trip to close on your house, just to name a few.

Send your resume in complete confidence, including salary history, to Mr. C. McGill, Martin Marietta Aerospace, P.O. Box 179, Mail #D-6310, Denver, CO 80201.

MARTIN MARIETTA

An Affirmative Action Employer actively seeking the Handicapped and Veterans

IMAGINE TOMORROW'S ENGINEERING



GOULD IS THERE TODAY!

Our engineers designed, manufactured and delivered the Mk48 torpedo ... on time and under budget! We are currently applying our total systems responsibility concept to many challenging defense systems programs both above and below water. This will assure the United States superiority into the 1980's. Our rapid expansion has created openings for U.S. Citizens experienced in the areas below.

- STATISTICS/MODELING
- DTC/LCC
- INFRARED
- ACOUSTICS
- FIBER OPTICS
- SYSTEMS INTEGRATION
- OPERATIONS ANALYSIS
- COMPONENTS
- AERO-HYDRO DYNAMICS
- STRUCTURED SOFTWARE
- COMPUTER ARCHITECTURE
- RELIABILITY
- SIGNAL & DATA PROCESSING
- WARHEAD SYSTEMS
- TEST & EVALUATION
- NON-METALLIC MATERIALS
- SAFETY & HUMAN FACTORS
- ELECTRO/MECHANICAL DESIGN

We will offer you an excellent salary, complete benefits and the advancement potential you would expect from a rapidly growing Fortune 200 company.

For further information send letter of inquiry and/or resume to:

Kathy A. Shook
Gould Ocean Systems Division
P.O. Box 17044
Euclid, Ohio 44117
or call Collect: 216-486-8300 Ext. 313

An Equal Opportunity Employer M/F/H

GOULD

Electronic Design

BRINGS YOU
THE HIGHEST
NUMBER OF
QUALIFIED EOEM
ENGINEERS AND
ENGINEERING
MANAGERS
ANYWHERE
. . . AT THE
LOWEST COST
ANYWHERE!

special late close

Recruitment advertisers have special "late close" priveleges in *Electronic Design.* Each issue closes only 14 days before mailing date. Don't get lost in general newspapers . . . go where you'll find *experienced* engineers ... You'll find them reading *Electronic Design!*

Join the leader...

Join the people who are revolutionizing the Navigation and Communication Systems of the world.

Today Magnavox Advanced Products Division is playing a key role in the most revolutionary advances in the history of navigation and position determination — the Navstar Global Positioning System. Navstar is an anti-jam, precise ranging system that will enable man for the first time to obtain instant, simultaneous determination of position and velocity even under severe dynamic conditions.

This represents an enormous advance for both military and commercial positioning worldwide. It is made possible by Navstar's successful merging of satellite navigation and spread-spectrum technologies; fields in which Magnavox exercises undisputed leadership.

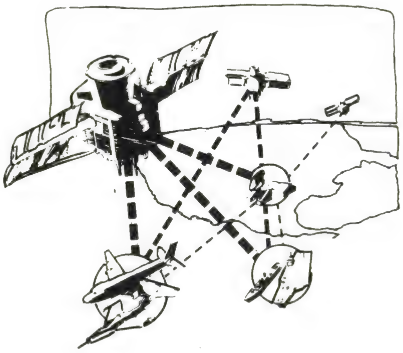
Global Positioning System

With the development of the NAVSTAR Global Positioning System — GPS — man will be able to fix the position, velocity, and time anywhere on earth, with unprecedented accuracy.

As development progresses, this system will replace the radio navigation systems currently in use. Current applications at MAGNAVOX range from man-packs to satellite sets for space application.

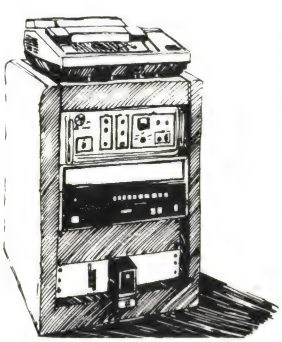
The Full Scale Engineering development of User Equipment for NAVSTAR-GPS is your opportunity to join a very successful electronics team in an environment conducive to your professional growth. Current career opportunities exist for:

Navigation Systems Analysts
Senior Systems Test Engineers
RF Design Engineers
Mechanical Systems Designers
Communications Systems Analysts
Packaging Design Engineers
Program Engineers
System Test and Integration



Communications Systems

We are developing, manufacturing, marketing, and supporting some of the most sophisticated communications systems ever conceived for the United States Government. MAGNAVOX's communications business applies advanced digital communications techniques, including: pseudo noise, spread spectrum anti-jam modulation to communications systems, both tactical and strategic.

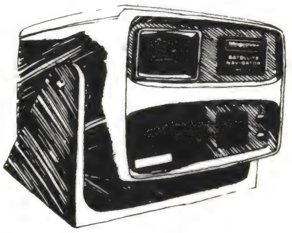


To continue development in this area, our Communications Systems Operation requires high caliber engineers. Current career opportunities exist for:

Communications Engineers
Communication Systems Analysts
Program Managers
System Test and Integration

Marine Systems

This area encompasses the development, production, sale and support of marine electronic products and systems to commercial and government interests. Our continuing research and development programs are producing the most sophisticated navigation and communications systems in the world.



Because of our commercial, industrial orientation, development is not controlled by large government contracts. Our engineers and programmers work in small, cohesive units which have team responsibility for new designs and their production.

The MAGNAVOX Marine Systems Operation is a strong, growing and technically sophisticated group. To support these activities, we need talented, hard working professionals in the following areas:

Digital Designers
Firmware Designers
Analog Circuit Designers
Software Engineers

If you're seeking a career where there's a diversity of technological challenges, complete involvement with projects from concept through production, a strong management team, career stability, and a stimulating environment, Join the Leader . . . MAGNAVOX.

You are invited to send your resume to:

Professional Placement
Dept. ED-280
2829 Maricopa Street
Torrance, CA 90503

We are an equal opportunity employer and encourage women, minorities and handicapped to apply.

Magnavox
Government and Industrial Electronics Company
Advanced Products Division

INNOVATORS... COME TO EMERSON

If you're an innovative, creative ATE Engineering professional, you owe it to yourself to check out the career opportunities at Emerson Electric Co., Electronics & Space Division. Long recognized as an industry leader, Emerson is also the nation's fastest growing company in its field. Emerson's growth and leadership position can be attributed to a sophisticated, state-of-the-art product line, a supportive management team and a staff of professionals dedicated to excellence and innovation.

We're looking for ATE engineers with experience in a variety of disciplines, including design, systems, software and mechanical design. Other positions are available for marketing pros with a background in engineering.

We provide a challenging career opportunity as well as an outstanding compensation package. If you're an innovator and ready for the next step in your career you're ready for Emerson.

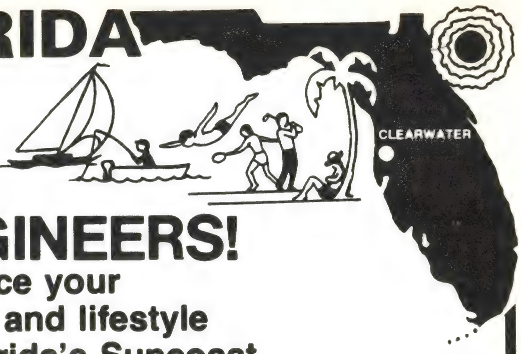
For more information, call or send your resume to:

Steve Subracko or Jim Lewis
(314)553-4304 or **(314)553-4303**

EMERSON ELECTRIC CO.
Station 4303
8100 Florissant
St. Louis, MO 63136
equal opportunity employer m/f

ELECTRONICS
AND
SPACE DIVISION
EMERSON

FLORIDA



ENGINEERS!

Advance your career and lifestyle on Florida's Suncoast.

AUTOMATIC TEST EQUIPMENT SYSTEMS

- Advanced software systems, including ATLAS compilers, translators, UNIX operating systems and test support designs.
- Software and firmware for microprocessor based controllers.
- Test set application software.
- Advanced pin electronics.
- Arbitrary waveform generators.
- Video signal generators.
- RF/Microwave receivers and generators.
- Flexible switching circuits from DC to RF.
- Systems engineering analysis and integration.
- Marketing

If you're a degreed engineer, send your resume, including salary history, in confidence, to Edward Vendley, Sperry Microwave Electronics, P.O. Box 4648, Clearwater, Florida 33518.

COME GROW WITH
SPERRY
MICROWAVE ELECTRONICS

Career opportunities also exist at:

SPERRY DIVISION
Great Neck, NY 11020
ATTN: P.W. Smith

NORTHERN VIRGINIA
OPERATIONS
5400 Cherokee Ave.
Alexandria, VA 22312
ATTN: R. Krakau

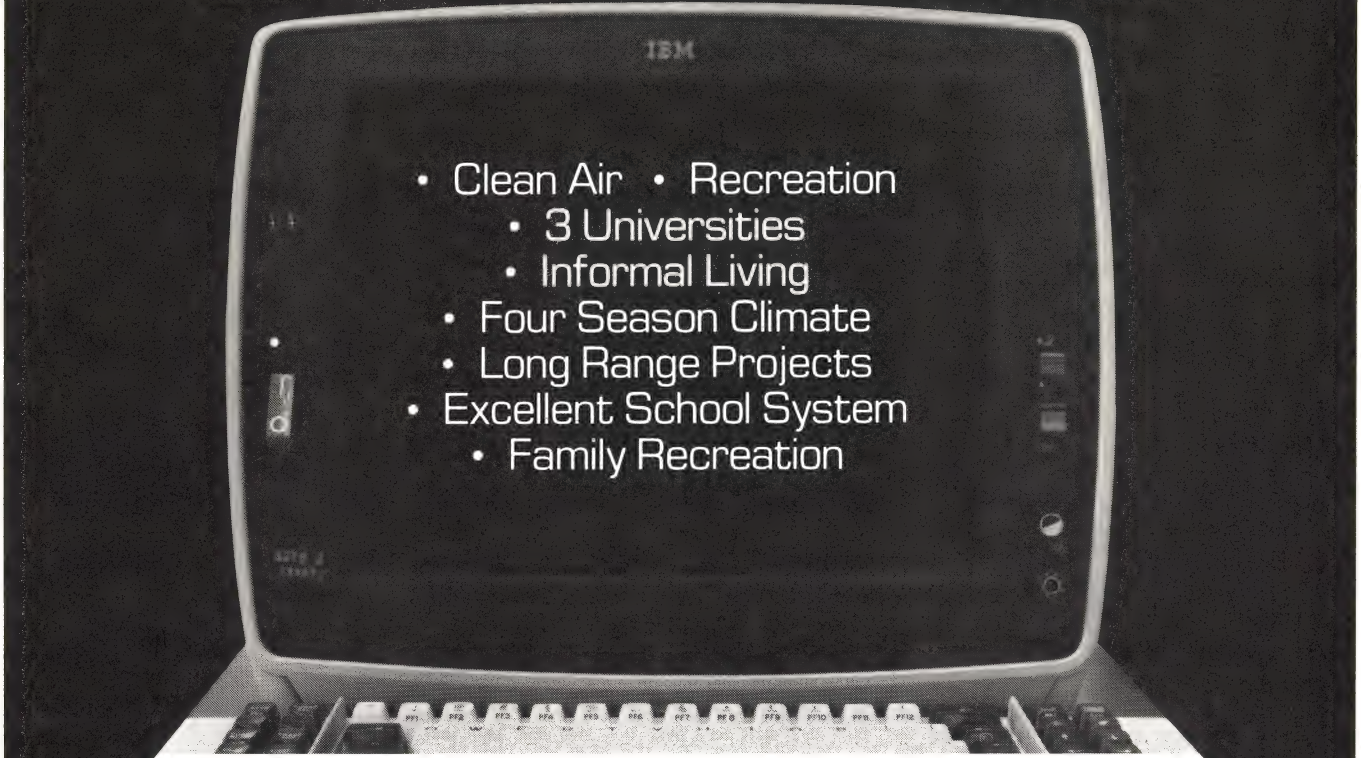
An equal opportunity employer M/F.

YOU REACH ENGINEERS WITH TITLES LIKE THESE:

• Chief Engineer • Development Engineer • Design Engineer
• Project Engineer • Electronic Engineer • Engineer-Supervisor
• Section Leader • Staff Engineer • Systems Engineer
• Test Engineer • Standards Engineer
• Master Engineer with Electronic Design

ENGINEERS:

COMPUTE THE ADVANTAGES OF BOEING IN WICHITA



- Clean Air
- Recreation
- 3 Universities
- Informal Living
- Four Season Climate
- Long Range Projects
- Excellent School System
- Family Recreation

The benefits of a career at Boeing Wichita make up quite an impressive display. Put together clean air, four season climate, big city living in a small town atmosphere plus the long range security of an expanding family of Commercial airplanes and sophisticated Military programs and you've got a career picture that's hard to beat.

Join these programs now while assignments are growing. Write or phone us today to find out how your experience and background can match our many requirements which are not limited to those listed below. We believe you'll be pleasantly surprised at the opportunity we have to offer at Boeing Wichita.

IMMEDIATE REQUIREMENTS include the following which require U.S. Citizenship and BS or higher degree in Engineering, Physics, Computer Science or Math

- **STRUCTURAL DESIGN**
- **STRESS ANALYSIS**
- **SOFTWARE DEVELOPMENT - DESIGN ANALYSIS**
- **PRODUCT SYSTEMS ENGINEER**
- **ELECTRICAL/ELECTRONIC INSTALLATION DESIGN**
- **GROUND SUPPORT REQUIREMENTS ELECTRICAL-ELECTRONICS**
- **INSTRUMENTATION DESIGN**
- **TECH WRITER - ELECTRONICS**
- **ELECTRONICS/ELECTRICAL TESTING**
- **FLIGHT SYSTEM TESTING**
- **INSTRUMENTATION TEST**
- **TEST PLANNING - ELECTRONICS**
- **CONTROL SYSTEM ANALYSIS**
- **ELECTRONIC SYSTEM ANALYSIS**
- **SYSTEM SAFETY**
- **POWER DISTRIBUTION ANALYSIS**
- **LIAISON ENGINEER**
- **MANUFACTURING RESEARCH & DEVELOPMENT ENGINEERS**

Send resume to: **Jim Snelling**
Boeing Military Airplane Company
4300 E. MacArthur Road, Dept. ED2
Wichita, Kansas 67210
or Call Collect (316) 687-3057

BOEING
MILITARY AIRPLANE COMPANY
WICHITA, KANSAS

An Equal Opportunity Employer M/F

If you currently earn between $22,000 and $48,000 we've got a better job for you...NOW!

Every day you spend in the wrong job is a waste of time, money and talent...YOURS! Your talents and experience are in great demand and you can choose among many rewarding opportunities available in your field. But how?

Talk to the experts at Wallach. We've been successfully recruiting professionals like yourself for over 15 years.

Nationwide opportunities include technical/management consulting, project management, R&D, test and systems evaluation in the fields of Communications, Satellites, Weapons, Intelligence, Computer, Energy, and Aerospace systems. Specific skill areas include:

- **Minicomputers**
- **Microprocessors**
- **Software development**
- **Signal processing**
- **Digital systems**
- **Command & Control**
- **Radar Systems**
- **Communication Systems**
- **EW/SIGINT/ELINT**
- **Microwave Systems**
- **Electromagnetics**
- **Fire Control Systems**

Don't waste another day in the wrong job! Call Robert Beach collect at (301) 762-1100 or send your resume in confidence. We can find you a better job. Let us prove it to you...NOW!

WALLACH...Your career connection

Equal Opportunity Employer Agcy.

WALLACH
associates, inc.

1010 Rockville Pike
Box 6016
Rockville, Maryland 20852
(301) 762-1100

ELECTRONICS ENGINEERS

CHALLENGING CIVIL SERVICE POSITIONS AT

ROBINS AIR FORCE BASE GEORGIA

IN THE FOLLOWING AREAS:

- ELECTRONIC WARFARE SYSTEMS
- RADAR SYSTEMS
- COMPUTER CONTROLLED WEAPONS SYSTEMS
- DIGITAL AVIONICS SYSTEMS
- AUTOMATIC TEST EQUIPMENT
- OPERATIONAL FLIGHT PROGRAMS
- COMMUNICATION-NAVIGATION SYSTEMS

Robins AFB is Georgia's largest employer and borders Warner Robins, Georgia. Middle Georgia offers high quality living at a moderate cost. It is an ideal location for a variety of outdoor activities with an average temperature of 65 degrees and an average yearly rainfall of 46.3 inches. Nearby facilities provide for fishing, hunting, golf, tennis, boating, and other leisure activities. With Atlanta just 100 miles to the north, professional sports and "big city" civic and cultural events are within easy reach. Salary range: $14,618 to $24,703. Excellent fringe benefits including relocation assistance. Applicants should have a degree or be a registered PE and be a U. S. citizen. All qualified applicants will receive consideration without regard to race, color, sex, national origin, age, marital status, nondisqualifying physical handicap, or political affiliation. Reply in confidence to: Warner Robins Air Logistics Center/DPCSC, Robins AFB, GA. 31098. Phone (912) 926-5711 or 5821.

HIGH ON THE LIST

of an engineer's required reading is Electronic Design. It is the **premier** magazine of the electronics field because it is . . .
First in market coverage — more circulation in the Electronic Original Equipment Market.
First in market penetration — more design and development engineers and managers than any other electronics magazine.
First in readership - better read in advertiser-initiated readership studies (158 **firsts** out of 182 over the past 19 years).
First in advertiser acceptance — more pages of advertising than any other electronics publication.

50 Essex Street, Rochelle Park, New Jersey 07662
Telephone (201) 843-0550 TWX 710-990-5071

If our name doesn't turn you on, our technology will.

We know that the word "radar" may remind you of yesterday.

But look beyond our name to the technologies we're involved with—that *you* can become involved with—at Hughes Radar Systems Group.

You'll discover that we're at the cutting edge of electronics, producing advanced radar systems for the aircraft of today, tomorrow, and on into the future.

Our systems are so advanced, we even have to design and produce our own special equipment to manufacture and test them.

We use both computer-aided design and computer-aided manufacturing, and we employ some of the most advanced component fabrication processes you'll find. Anywhere.

What about the technologies and processes of tomorrow? That's why we need you—and your imagination.

We'll furnish every tool, every opportunity, and every incentive for professional growth and advancement.

With a backlog of over four *billion* dollars and more than 1500 varied projects in the works, our needs are many and cover most disciplines—from electronics to mechanical to computer professionals. Whatever your specialty, we probably have the right spot for you.

Forget any misconceptions you may have had about "radar." At Hughes RSG it means *leadership.*

Send your résumé now to
Hughes Aircraft Company,
Radar Systems Group, Dept.
DE-2, P.O. Box 92426, Los
Angeles, CA 90009.

Hughes is an equal opportunity employer m/f/h. U.S. citizenship required.

RADAR SYSTEMS GROUP

HUGHES

HUGHES AIRCRAFT COMPANY

AUTOMATIC TEST ENGINEERS

DARE TO EXCEL!

If your priorities are: TECHNICAL CHALLENGE - CAREER ADVANCEMENT - EXCELLENT COMPENSATION & BENEFITS - PERSONAL RECOGNITION & REWARD - NEED TO ACHIEVE - LONG TERM PROGRAMS...

Consider Northrop Defense Systems Division in Rolling Meadows, Illinois where high technology is a way of life. We are seeking professionals with the following backgrounds:

ATE Systems Engineering

Digital Test - Systems analysis, Development and Integration of ATE for Digital Test including Automatic Test Generation, Test Instrumentation/Software.

Analog Test - Systems Analysis, Development and Integration of ATE for analog Test including Waveform Analysis/Test Instrumentation/Software.

RF (Microwave) Test - Systems Analysis, Development and Integration of ATE for Microwave Test including RF Spectral Analysis/Test Instrumentation/Software.

ATE Design Engineering

Electrical -Analysis, Design, Development, and Integration of special Test Instrumentation and Interface Adapters including validation of Test Packages.

Mechanical -Packaging Design, Development, and validation of Test Instrumentation/Test Adapters.

ATE Software

Analog Test - Design, code, debug, verify and document diagnostic test procedures for component level fault isolation. Use BASIC, FORTRAN IV and HP Assembler.

Digital Test - Design, code, debug, verify and document diagnostic test procedures for component level fault isolation. Use ATLAS, TEST-AID, F ASTRACE, BASIC FORTRAN IV and HP Assembler.

At Northrop, we offer the right combination of freedom to excel, rapid and stable growth built around long range programs, while you enjoy the excitement of Chicago's cosmopolitan array of cultural and recreational life styles, made possible through a generous salary and benefits program which includes dental and savings plans. If we've peaked your curiosity, don't hesitate to send your resume and salary considerations to: PROFESSIONAL EMPLOYMENT MANAGER, Dept. E2D.

NORTHROP CORPORATION
DEFENSE SYSTEMS DIVISION
600 Hicks Road, Rolling Meadows, IL 60008

as an equal opportunity employer, we encourage minorities and females to apply.

NORTHROP

Bipolar IC Design Manager

Putting It All Together!

Vancouver, Washington

People and technology merge to form a unique association at National. We've truly put it all together for achievement-oriented professionals desiring complete careers.

You'll be responsible for staffing and managing a new bipolar logic design department in Vancouver, Washington. This group will design and develop new and standard products, develop/implement digitizing/layout-oriented CAD tools, and eventually broaden from bipolar into MOS technology. Requires a BS/MSEE and 8-10 years of IC design experience, primarily in digital and interface products. Candidates should possess three or more years of supervisory experience.

We offer an exceptional compensation package and rapid advancement potential in a highly visible environment. Start putting it all together by calling **Bob Hasselbrink, COLLECT, at (408) 737-5640** or send your resume to his attention at: **National Semiconductor, 2900 Semiconductor Drive, Santa Clara, California 95051.** An equal opportunity employer m/f/h.

National Semiconductor

PUBLISHED EVERY TWO WEEKS

Because there is an issue of **Electronic Design** published every two weeks — 26 times a year — your help-wanted message gets into the marketplace quickly, yet gains the impact that only a technical journal can provide.

Engineers . .

Engineers . .

Engineers . .

Gathered in one place ...

. . . not scattered about among costly and unwieldy newspaper audiences

. . . but concentrated selectively for easy reach

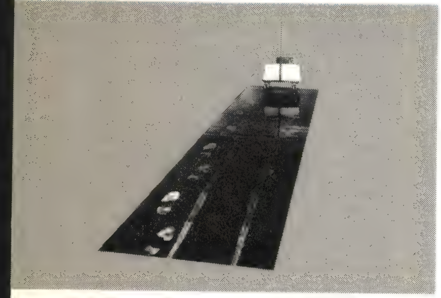
. . . in the proper frame of mind

To fill a big job, use a big medium
Recruiting . . . in the pages of Electronic Design, the best-read electronics publication in the world.

50 Essex Street, Rochelle Park, New Jersey 07662
Telephone: (201) 843-0550 **TWX 710-990-5071**

quick ads

New and current products
for the electronic designer
presented by their manufacturers.

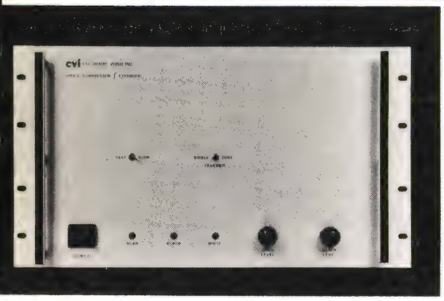


S CLEAN-ROOM TRAP DUST MAT protects m traffic born contamination. Pulls dust, t, even bacteria from shoes, trolley wheels. ed without fixtures at entrances to con- mination sensitive areas. Fully washable d re-usable. Genuine Swiss made. Un- ualed for durability, wear resistance. SAT pirig) Inc., 357 Cottage St, Springfield, MA 104 (418) 788-6191 TWX-710-350-6466 rig P.O. Box 160 CH 8640 Rapperswil, itzerland (055) 274403 Telex 875400

ST TRAP MAT 132

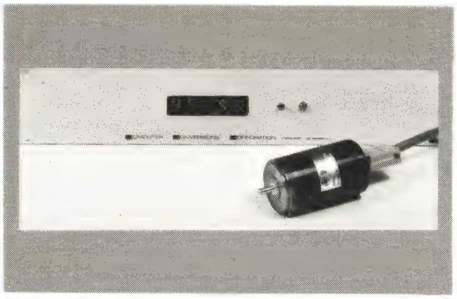
ODEL NO. 720 AN AUTOMATIC TEST EQUIP- ENT OF CREATIVE TECHNOLOGICAL EX- ERIENCE Automatic circuitmaster for com- lex wiring harness harness assemblies, ables, P.C. boards with or without compo- ents. Capacity 64 circuits to 9000 circuits. BC Digital Electronics, Inc., 77 Brookside lace, Hillsdale, N.J. 07642 Tel: (201) 66-2458

UTOMATIC CIRCUITMASTER QC 720 133



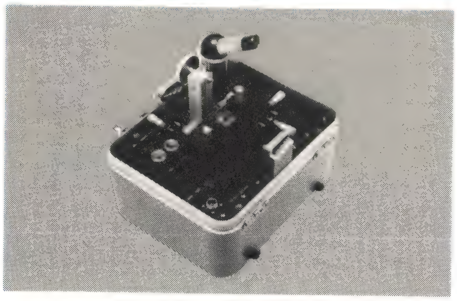
ODEL 280 VIDEO TRANSCEIVER. Model 280 ransceiver allows video teleconferencing ver normal, dial-up telephone lines, and ombines three functions: freezes a single rame of video; converts the picture for trans- mission over audio channels; receives and econverts these signals to conventional TV tandards. Sends 256 × 256 picture elements n 35 seconds; 256 × 512 in 74 seconds. Full pecifications on request. Colorado Video, ox 928, Boulder CO 80306 USA; phone 03/444-3972.

VIDEO TRANSCEIVER 134



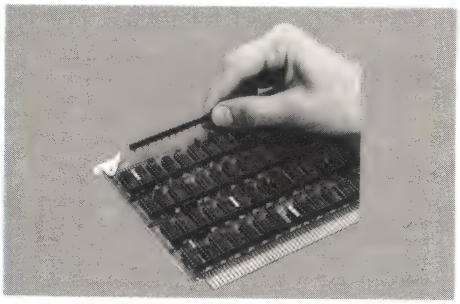
MULTI-TURN ABSOLUTE ENCODER ±1 part in 100,000 system accuracy — Electro-Magnetic Transducer +5 digit LED Display + BCD, Binary, and DC output — 10, 64 or 100 turns — adjustable scale factor (0 to 999,999) — Hi noise immunity — zero offset — unambigious crossovers. Units less than $995.00/axis. Send for Free Catalog & Application Notes. Computer Conversions Corporation, East Northport, N.Y. 11731 — (516) 261-3300

MULTI-TURN ABSOLUTE ENCODERS 135



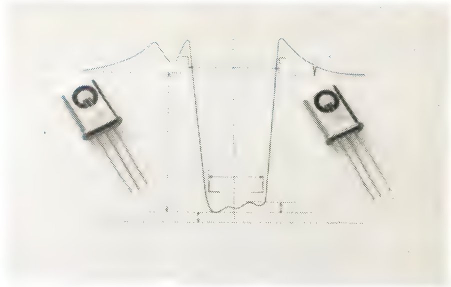
The Model PFS-200 represents the state of the art in optical fiber splicing. From assembly line production to the rugged environment of field repair, the PFS-200 will consistently provide low loss splices (as low as .05db). Since it splices all fibers, single or multi-mode, quartz or silica, the PFS-200 is the only splicing device you need. Power Technology Incorporated, P.O. Box 4403, Little Rock, AR 72214 (501) 568-1995.

OPTICAL FIBER SPLICER 136



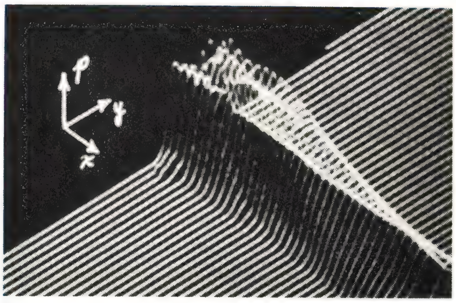
Q/PAC ELEMENTS. Q/PAC™ power distribution elements obsolete decoupling capacitors, eliminate on-board power and ground traces and extra board layers. Q/PAC elements maximize packaging density; minimize signal interconnection problems. Capacitance values to 0.05 μf per inch; lengths to 16″. Contact Q/PAC product specialist at ROGERS CORPORATION, Chandler, AZ. 85224, (602) 963-4584. Europe: Mektron N.V., Gent, Belgium. JAPAN: Nippon Mektron, Tokyo.

Q/PAC ELEMENTS 137



MONOLITHIC CRYSTAL FILTER Low cost 10.7 MHz monolithic crystal filter, model 10.7-15A, ± 7.5 KHz at 3 db band width, ± 25 KHz at 18db, 0.5 db ripple, 2 db insertion loss, 3 K ohm impedence. Off shelf delivery at $2.50 each for 100 pcs or more. Two filters connected in cascade exhibit ± 25 KHz at 40 db, ripple less than 1 db, insertion loss less than 2.5 db. Q-MATIC CORPORATION, 3194 D AIRPORT LOOP DRIVE, COSTA MESA, CA. 92626, (714) 545-8233, TELEX 678-389

CRYSTAL FILTER 138



ELECTRONIC ISOMETRIC PROJECTOR generates 3D images of data applied to X, Y, Z inputs. Single-wide plug-in fits the Tektronix TM500 system. Image can be rotated, tilted, and magnified with front panel controls for optimum view. Image may be presented on CRT display, recorder, etc. Input and output offset controls are incorporated. Applications include ultrasonic field mapping and imaging, infrared imaging, eddy current testing, scanning electron microscopy. METROTEK, INC. (509) 946-4778

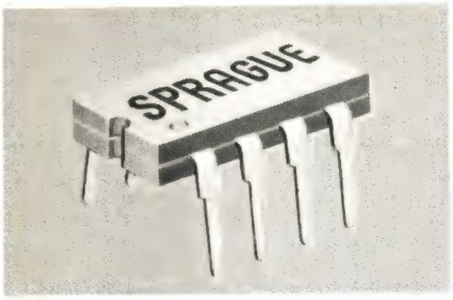
ISOMETRIC PROJECTOR 139

ATOMIC FREQUENCY STANDARDS. Stability: 1 x 10^{-11}/month, 1 x 10^{-12} τ, Frequency: 2 x 10; 5; 1; 0-1 MHz, Option: 1 PPS, Temperature: <1 x 10^{-10} from −10°c to +50°c, Internal Battery: 5 hours of operation, Automatic recharge. APPLICATIONS, Lab/Field calibration; offshore marine navigation and positioning, satellite and secure communications systems.
EFRATOM, 18851 Bardeen Ave., Irvine, Calif. 92715 phone 714/752-2891

FREQUENCY STANDARDS 140

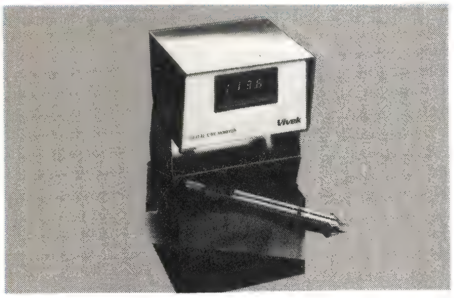
quick ads

New and current products
for the electronic designer
presented by their manufacturers.



DUAL PERIPHERAL AND POWER DRIVERS. Series UDN-3600M "mini-DIP" dual 2-input peripheral/power drivers are bi-polar ICs incorporating AND, NAND, OR, or NOR logic gates and high-current switching transistors on same chip. Output transistors simultaneously sink 300 mA continuously at ambient temperatures to +70°C. Write for Bulletin 29,308. Sprague Electric Co., 347 Marshall St., North Adams, Mass. 01247. (413) 664-4411.

PERIPHERAL/POWER DRIVERS 141

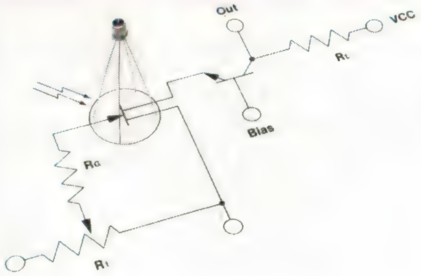


ECONOMICAL DIGITAL LINE MONITOR Don't tie up an expensive test meter as a line monitor. Plug in a Vivek 402 and get continuous read-out of incoming voltage. This precision instrument has 0.3" LED digital display for error free reading. Accuracy of the meter is 0.5%. Vivek 402 is not a panel meter. It comes complete with tilt bracket for wall or shelf mounting. Cost is a low $129.50. For free 15 day trial and further information contact: Vivek Division Viva-Tech, Inc. 34 Elton St. Rochester, N.Y. 14607 (716) 460-5660

LINE VOLTAGE MONITOR 142

6800/6801 Micro Software *** CROSS SOFTWARE *** 6800/6801 assembler...$400., PL/W compiler...$1400., cross linker...$400., math/science...$500., simulator...$800., *** RESIDENT SOFTWARE *** editor/assembler...$95., industrial 4K Basic...$95., in ROM...$299. WINTEK CORP. 1801 South Street, Lafayette, In. 47904 (317) 742-8428.

Micro Software 143



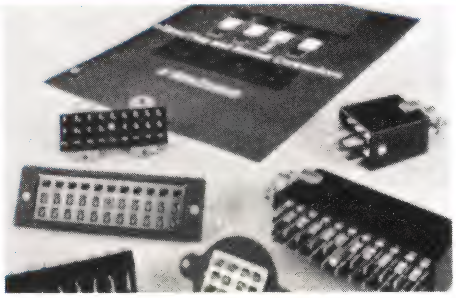
Supersensitive Photo FETs Light sensitive, N-Channel, junction FETs. Ideal for optical coupling applications demanding supersensitivity, fast response (TR 25 nSec typical), low dark current and near zero TC stability. Much more sensitive than conventional bipolar optical devices, with sensitivity adjustable over ranges up to 10^6 to 1, and with three times higher gain bandwidth. Teledyne Crystalonics, 147 Sherman St., Cambridge, MA 02140. Tel: (617) 491-1670.

SUPERSENSITIVE PHOTO FETs 144

POWER/MATE MAKES SWITCHER HISTORY.
5 Volts 10 Amps
$89.
THE SWITCHER COST BREAKTHROUGH YOU'VE BEEN WAITING FOR!
POWER/MATE CORP.
POWER/MATE MAKES MULTIPLE OUTPUT SWITCHER HISTORY.
Five Regulated Outputs 100 Watts
$199.
THE SWITCHER COST BREAKTHROUGH YOU'VE BEEN WAITING FOR!
POWER/MATE CORP.

NEW SWITCHING POWER SUPPLY CATALOGS introduce the single and multiple output switching power supplies that break the switcher price barrier wide open! Top quality open-frame switching supplies with exceptional efficiency and compactness ...yet they are competitive in price with many frame linear supplies. MTBF well over 50,000 hrs.. Two-year Warranty. Meet UL and CSA standards. Power/Mate Corp., 514 South River St., Hackensack, NJ 07601 (201)440-3100.

POWER SUPPLY CATALOGS 145



24-PAGES ON PLUGS Beau plug and socket connectors. Compared to Jones, there are many differences. Like standard pre-grounding connectors. The safety and resilience of thermoplastic backshells. All our plugs have uniform-float contacts for low resistance, and smooth, easy mating. And the widest choice of contact tails. Beau gives you more choices. More design advantages. More quality. Beau Products Div., Vernitron Corp., Box 10, Laconia, NH 03246, (603) 524-5101.

CONNECTORS 146

Electronic Desig

Advertising Sales Staff
Rochelle Park, NJ 07662
Eastern Regional Sales Manager:
Thomas P. Barth
Robert W. Gascoigne
Constance McKinley, Becky McAdar
Roberta Renard, Stan Tessler
Diana Andress, Carol Helton
Sales Assistants:
Deborah DiPilla, Francine Guerra
Dale Siegel, Betsy Tapp
50 Essex St.
(201) 843-0550
TWX: 710-990-5071
(HAYDENPUB ROPK)
Philadelphia
Thomas P. Barth (201) 843-0550
Boston
M. E. "Casey" McKibben, Jr.
113 River St.
Waltham, MA 02154
(617) 893-4441
Chicago 60611
Thomas P. Kavooras
Craig L. Pitcher
Sales Assistant:
Christine Perkins
200 East Ontario
(312) 337-0588
Cleveland
Thomas P. Kavooras (312) 337-058
Texas
Craig L. Pitcher (312) 337-0588
Los Angeles 90045
Stanley I. Ehrenclou, Burt Underwo
Sales Assistant:
Betty Fargo
8939 South Sepulveda Blvd.
(213) 641-6544
San Francisco
Western Regional Sales Manager:
Robert A. Lukas
Neal Manning
Sales Assistant:
Nancy Miguelgorry
1307 South Mary, Suite 212
Sunnyvale, CA 94087
(408) 736-6667
United Kingdom-Scandinavia
Constance McKinley
Germany
Annemarie McCalla
50 Essex St.
Rochelle Park, NJ 07662
(201) 843-0550
Europe
W.J.M. Sanders
S.I.P.A.S.
Raadhuisstraat 24 - P.O. Box 25
1484 EN Graft-de-Ryp, Holland
Tel: 02997-1303 and 3660
Telex: 13039 SIPAS NL
Telegrams: SIPAS-Amsterdam
Annick Wolff
Promotion Presse Internationale
7 ter Cour des Petites Ecuries
75010 Paris, France
Telephone: 247-12-05
Robert M. Saidel
Technimedia International
Piazzale Cadorna 4,
20123 Milan, Italy
Tel: 80 16 46
Telex: 25897 Utidioma
Tokyo
Haruki Hirayama
EMS, Inc.
5th Floor, Lila Bldg.,
4-9-8 Roppongi
Minato-ku, Tokyo, Japan
Phone: 402-4556
Cable: EMSINCPERIOD, Tokyo
Recruitment Advertising Manager
Roberta Renard (201) 843-0550

ABP BPA

lectronic Design

LECTRONIC DESIGN'S function is:
To aid progress in the electronics manu-
cturing industry by promoting good de-
gn.
To give the electronic design engineer
ncepts and ideas that make his job easier
d more productive.
To provide a central source of timely
ectronics information.
To promote communication among mem-
rs of the electronics engineering com-
unity.

ant a subscription? ELECTRONIC DESIGN
circulated free of charge to those individ-
ls in the United States and Western
urope who function in design and develop-
ent engineering in companies that in-
rporate electronics in their end product
d government or military agencies in-
lved in electronics activities. For a free
bscription, use the application form
und in the back of the magazine or write
r an application form.
you do not qualify, paid rates for a year's
bscription (26 issues) are as follows: $35.
S., Canada, Mexico, Central America.
ternational annual subscription rates
sted below include air delivery: $65. Eu-
pe; $100. Mideast, North Africa, South
merica, Japan; $130. Central and South
frica, New Zealand, Australia and all
her Asia. Single copies (when available)
ay be purchased for $4. U.S., Canada,
exico, Central America and $5. in all other
untries. The GOLD BOOK (27th issue)
ay be purchased for $35. U.S., Canada,
exico, and $45. all other countries.

you change your address, send us an old
ailing label and your new address; there
a card bound into the back of the magazine
r this purpose. Please allow 6 to 8 weeks
r address change to become effective. You
ust requalify in order to continue receiv-
g ELECTRONIC DESIGN free of charge.

he accuracy policy of ELECTRONIC DESIGN
:
To make diligent efforts to ensure the
ccuracy of editorial matter.
To publish prompt corrections whenever
accuracies are brought to our attention.
orrections appear in "Reader Feedback."
To encourage our readers as responsible
embers of our business community to
eport to us misleading or fraudulent ad-
ertising.
To refuse any advertisement deemed to
e misleading or fraudulent.

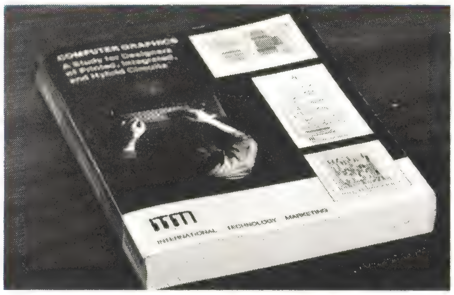
ndividual article reprints and microfilm
opies of complete annual volumes are avail-
ble. Reprints cost $6.00 each, prepaid ($.50
or each additional copy of the same article),
o matter how long the article. Microfilmed
olumes cost $23 for 1976 (Vol. 24); $30 for
973-75 (Vols. 21-23), varied prices for
952-72 (Vols. 1-20). Prices may change. For
urther details and to place orders, contact
ustomer Services Dept. University Micro-
ilms, 300 N. Zeeb Rd., Ann Arbor, MI 48106.
313) 761-4700.

Want to contact us? If you have any comments or wish to submit a manuscript or article outline, address your correspondence to:

Editor
ELECTRONIC DESIGN
50 Essex St.
Rochelle Park, NJ 07662

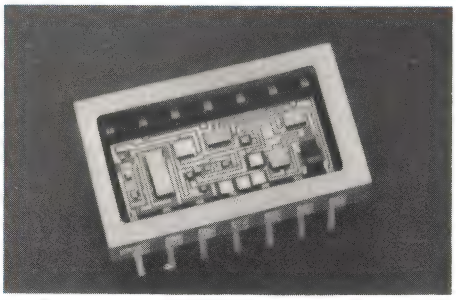
quick ads

New and current products for the electronic designer presented by their manufacturers.


COMPUTER GRAPHICS
A Study for Designers of Printed, Integrated, and Hybrid Circuits
ITM
INTERNATIONAL TECHNOLOGY MARKETING

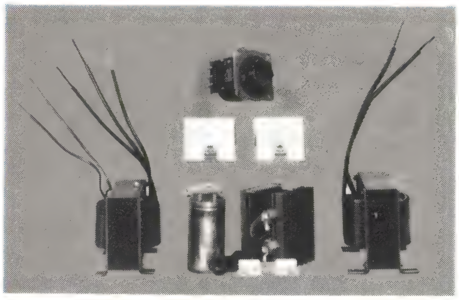
COMPUTER GRAPHICS: A Study for Designers of Printed, Integrated and Hybrid Circuits. • Comprehensive 450-page report. • Surveys and evaluations of interactive systems, hardware, software, services. • Trends: automated placement and routing of PCBs, hybrid circuits, IC design systems. • Design requirements, cost effectiveness, system selection. INTERNATIONAL TECHNOLOGY MARKETING, 120 Cedar St., Wellesley Hills, MA 02181. Tel: (617) 237-2089

COMPUTER GRAPHICS 147



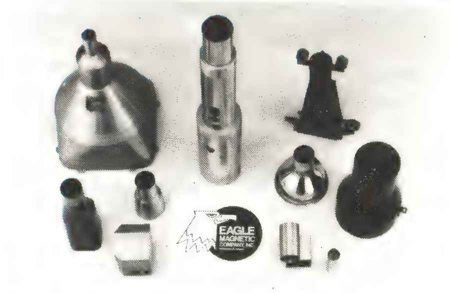
1.0 μSec 12 Bit Sample/Hold Amplifier MN346 12 Bit sample/hold amplifier offers the designer a 1.0 μSec acquisition time (to ±0.01%) and the convenience and low cost of a 14 pin DIP, including internal hold capacitor. Available for operation over the −55 to +125°C range and processed to MIL-STD-883, Method 5008, for military and other high reliability applications. $56.00/100's. Micro Networks Company, 324 Clark St., Worcester, MA 01606. Tel: (617) 852-5400.

SAMPLE/HOLD AMPLIFIER 148



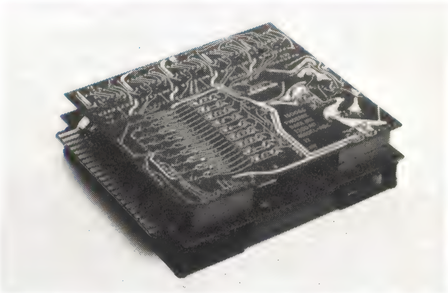
DC POWER SUPPLIES IN KIT FORM. Now available—major component groups as used in our standard production units. These can be incorporated into your consoles, plating benches and special configurations. Includes meters, silicon diodes mounted on adequate heat sinks, isolation transformers and stepless auto transformer voltage controls in a wide variety of DC outputs. Write for complete catalog of electroplating equipment. HBS EQUIPMENT DIVISION, DEPT. 543, 3000 Supply Ave., Los Angeles, CA 90040 (213) 726-3033

See us at NEPCON, Booth 872. 149



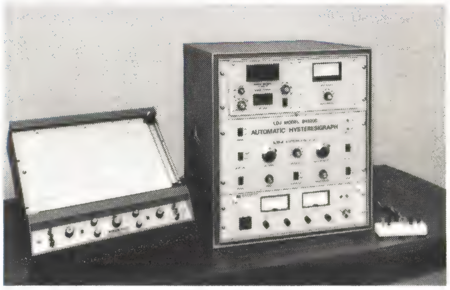
MAGNETIC SHIELDING Take advantage of Eagle's 23-year background in shield design and production. Custom and standard models. Full service includes design, engineering, fabrication, heat treating, finishing, testing. Also wide selection of sheet and foil so you can form your own shields. For helpful design and cost data, request Bulletin E-77. Eagle Magnetic Co., Inc., Box 24283, Indianapolis, IN 46224, 317-297-1030.

MAGNETIC SHIELDING 150



NEW 1215 A/D CONVERTER IS A HIGH-PERFORMANCE UNIT for digitizing high-speed broad-band analog input signals. Resolution: 1 part in 32,767; accuracy ±0.0065%; conversion time: 10 μsec; output codes: 2's complement or offset binary. ADC 1215 utilizes a single fold-back technique in conjunction with successive approximation conversions to achieve an equivalent conversion rate of 625 nanoseconds per bit. PHOENIX DATA, INC., 3384 W. Osborn, Phoenix, AZ 85017. PH 602/278-8528.

A/D CONVERTER 151



LDJ Model 5200 Automatic Hysteresigraph

Automatically Plots Hard or Soft BH curves, reduces human error, direct calibration in gauss and oersteds, digital readouts, variable speed and current limit, plots minor loops and recoil slopes.

For further information and for all your magnetic instrumentation needs, call the LDJ Electronics Applications Engineering Department (313) 689-3623 1064 Naughton Troy MI 48084.

AUTOMATIC HYSTERESIGRAPH 152

Advertiser's Index

Advertiser	Page
ABC Digital Electronics	141
AMP, Incorporated	48A-D
Adret Corporation	16E
Advanced Micro Devices	6-7
Alco Electronic Products, Inc.	121
American Microsystems, Inc.	16D-E
Ampex Memory Products	112F-G
Beau Prods., Div., Vernitron, Corp.	142
Bourns, Inc.,	Cover IV
Burndy Corporation	16B-C
Burr-Brown Research Corporation	15
CTS Keene, Inc.,	95
Centralab Electronics Division of Globe-Union, Inc.	112D-E
Colorado Video Inc.	141
Computer Conversions Inc.	141
Custom Connector Corporation	68
Cybernetic Micro Systems	110
Datel Intersil	82-83, 89
Dialight, A North American Philips Company	10
Dit Mco International	14
E-Z Hook	126
Eagle Magnetics, Inc.	143
Eaton Corp., Semiconductor Test Systems Div.,	21
Efraton California, Inc.	141
Elevan Electronic Tube Co., Ltd.	107
Ericksson, LM, Telematerial AB, Components Dept.	*32F
Fairchild Semiconductor, Operations Div.,	8-9
Fluke Mfg. Co., Inc., John	90-91
G. R. Electronics Ltd.	122
General Instrument Corp., Microelectronics Div.	12-13
Genrad, Inc-Corporate	116-117
Gold Book, The	127, 128
Gould, Inc.	32R
Gould, Inc., Instruments Division	58
Gould, Inc., Santa Clara	118
Guardian Electric Manufacturing Company	18
Gulton Industries, Inc.	112
H. B. S. Equipment	143
Harris Semiconductor, A Division of Harris Corporation	69
Hayden Publishing Company, Inc.	111, 122
Haydon Switch & Instrument, Inc.	120
Hewlett-Packard	1
Hitachi Electronics Co., Ltd.	112A-B
Hybrid Systems Corporation	40
Instrumentation Engineering Inc.	100
Intel Corporation	16F-G, 32, 32P-Q
Intelligent Systems, Inc.	127
International Crystal Mfg. Co.	119
International Technology Mktg.	143
Intersil	62-63
Italtel	*32B
Kepco, Inc.	34
Key Tronic Corp.	16
Keystone Carbon Company	30
Krohn-Hite Corporation	25
LDJ Electronics, Applications Engineering Dept.	143
Lewisystems, Menasha Corp.,	102
Methode Electronics, Inc, Trace Instruments	97
Metrotex	141
Microcomputer Rentals	118
Micro Networks Corporation	143
Mini-Circuits Laboratory, A Division of Scientific Components Corp.	4, Cover III
Mostek Corporation	27, 29, 124-125
MuRata Corporation of America	112H
Novotechnick KG	*32L
OPTO 22	47
Olivetti Corp.	16A
PPG Industries, Inc.	49
PTK Corp.,	108
Phoenix Data, Inc.	143
Plessy Capacitors, Inc.	*32
Power Dynamics Corp.	119
Power/Mate Corp.	142
Power Technology, Inc.	141
Pro-Log Corporation	103
Q-Matic Corp.	141
RCA	32 0
Rental Electronics, Inc.	70-71
Rockwell International	10
Rogers Corporation	74, 141
Simpson Electric Company	31
Spirig	141
Sprague Electric Company	99, 142
Standard Microsystems, Corp.	Cover II
Stevens Tubing Corp.	126
Super Tex, Inc.	84
Systron-Donner, Instrument Div.,.	104-105
T-Bar, Incorporated	114
TL Industries, Inc.	111
TRW/Options	11
TRW/LSI Products	56-57
Tecnetics, Inc.	113
Tecknit	38
Tektronix, Inc.	37, 64, 92-93
Tektronix, International	32K
Teledyne Crystalonics	142
Teledyne Relays	2
Teradyne, Inc, Memory Products Group	72-73
Texas Instruments, Incorporated	80-81
Thermosen, Inc.,	121
Union Carbide, Electronics Div., Components Department	22, 128
Vitramon North American Division of Vitramon Incorporation	17
Viva-Tech Inc.	142
Wells Electronics Inc.	120
Wintek Corporation	142

Recruitment

Allen-Bradley Col.	132
Boeing Military Airplane Co.	137
Emerson Electric Dol.	136
Gould Ocean Spray Div.	134
Genrad, Inc.	132
Hughes	139
Leonard, Frank Personnel	130
Magnavox, Advanced Products, Div.	135
Marietta, Martin Arrspace	133
National Semiconductor	140
Naval Research Laboratory	130
Northrop Corp., Defense Systems Div.	140
Robins Airforce Base	138
Sperry Microwave Electronics	136
Wallach Associates, Inc.	138

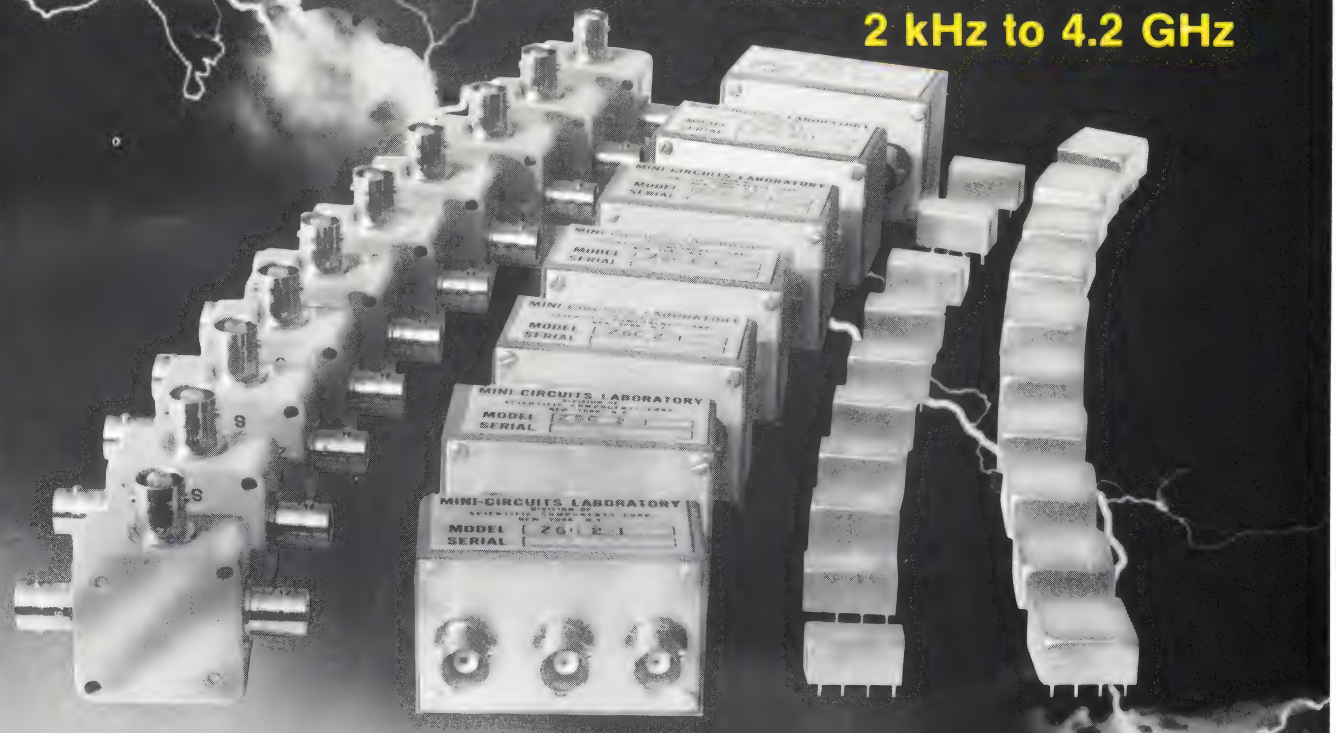
**Advertisers in International Edition*

Power Splitters in a flash!

ONE WEEK DELIVERY

Select from hundreds of models

2 kHz to 4.2 GHz



Series may include several models to cover frequency range. To select appropriate model, see MicroWaves Product Data Directory Pages 161-369, or EEM pages 2770-2970, or consult factory.

Series	Output Ports	Phase Degrees	Freq. Range	Connector	Models start from Price (Qty.)
PSC-2	2	0	2 kHz-1000 MHz	8 pin	$ 9.95 (6-49)
MSC-2	2	0	100 kHz - 650 MHz	8 pin	$16.95 (5-24)
ZSC-2	2	0	2 kHz-650 MHz	BNC,TNC	$27.95 (4-24)
ZMSC-2	2	0	2 kHz-650 MHz	SMA	$37.95 (4-24)
ZFSC-2	2	0	2 kHz-1500 MHz	BNC, TNC, N, SMA	$31.95 (4-24)
ZAPD	2	0	0.5 GHz-4.2 GHz	BNC, TNC, SMA, N	$39.95 (1-9)
PSCQ-2	2	90	12 MHz-180 MHz	8 pin	$12.95 (5-49)
ZSCQ-2	2	90	25 MHz-180 MHz	BNC, TNC	$39.95 (4-24)
ZMSCQ-2	2	90	25 MHz-180 MHz	SMA	$49.95 (4-24)
PSCJ-2	2	180	10 kHz-200 MHz	8 pin	$19.95 (5-49)
ZSCJ-2	2	180	10 kHz-200 MHz	BNC, TNC	37.95 (4-24)
ZMSCJ-2	2	180	10 kHz-200 MHz	SMA	$47.95 (4-24)
ZFSCJ-2	2	180	1 MHz-500 MHz	BNC, TNC, SMA.N	$39.95 (4-24)
PSC-3	3	0	10 kHz-500 MHz	8 pin	$19.95 (5-49)
ZSC-3	3	0	10 kHz-200 MHz	BNC, TNC	$37.95 (4-24)
ZMSC-3	3	0	10 kHz-200 MHz	SMA	$47.95 (4-24)
ZFSC-3	3	0	1 MHz-750 MHz	BNC, TNC, SMA, N	$39.95 (4-24)
PSC-4	4	0	10 kHz-1000 MHz	8 pin	$23.95 (6-49)
ZSC-4	4	0	2 kHz-250 MHz	BNC, TNC	$43.95 (4-24)
ZMSC-4	4	0	2 kHz-250 MHz	SMA	$53.95 (4-24)
ZFSC-4	4	0	1 MHz-1000 MHz	SMA, BNC, TNC, N	$74.95 (1-4)
PSC-6	6	0	1 MHz-175 MHz	16 pin	$68.95 (1-5)
ZFSC-6	6	0	1 MHz-175 MHz	BNC, TNC, SMA	$89.95 (1-4)
PSC-8	8	0	0.01 MHz-500 MHz	16 pin	$68.95 (1-5)
ZFSC-8	8	0	0.01 MHz-700 MHz	BNC, TNC, SMA	$89.95 (1-4)
ZFSC-16	16	0	500 kHz-125 MHz	BNC, TNC, SMA	$174.95 (1-4)
ZFSC-24	24	0	200 kHz-100 MHz	BNC, TNC, SMA	$264.95 (1-4)

Photograph by Harold M. Lambert

2 to 24 way models pin or connector versions . . . from $9.95

2-way to 24-way, 0°, 90°, 180°, pin or connector models . . . Mini-Circuits offers a wide variety of Power Splitters/Combiners to chose from . . . . with immediate delivery. But there are always "special" needs for "special applications" . . . higher isolation, SMA and Type N connectors intermixed, male connectors or wider bandwidths. Contact us. We can supply them at your request . . . with rapid turnaround time.

World's largest manufacturer of Double-Balanced Mixers

Mini-Circuits

MINI-CIRCUITS LABORATORY

2625 E. 14th St Brooklyn, New York 11235 (212) 769-0200
Domestic and International Telex 125460
International Telex 620156

Y44/Orig

CIRCLE NUMBER 100

New Hybrid Modular Pot...

For long life, infinite resolution, low TC and tight linearity.

Now there's a new element in the Bourns Model 80 family of modular pots. It's the Model 83/84 10-turn modular pot with the exclusive Bourns Hybritron® resistance element combining the best of both worlds . . . wirewound and conductive plastic.

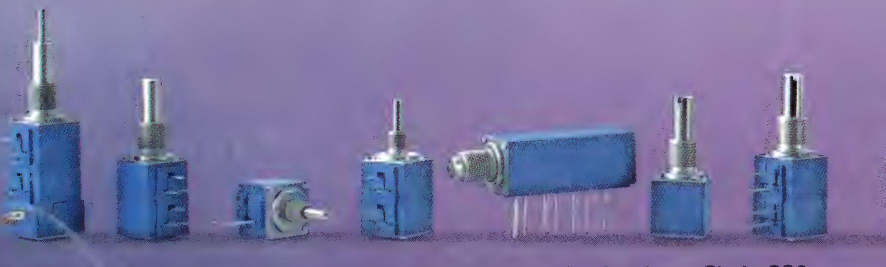
The Hybritron element displays the long operational life (4,000,000 shaft revolutions), essentially infinite resolution and low noise characteristics of a pure conductive plastic element. It also exhibits the low tempco (+100 ppm/°C), tight linearity (±0.25% max) and resistance stability approaching that of a pure wirewound element.

There's more. The Model 83/84 Hybritron pot is available with either PC pins or solder lugs. As with all of the Model 80's, it requires only one mounting hole and occupies just a ⅝" square area on the panel. It can be ganged up to two modules and is fully compatible with all other members of the Model 80 family, including combinations of 10-turn, single turn or switch modules. Priced just slightly higher than the Model 83/84 wirewound style, it's available in standard resistance values from 1K to 100K with various options.

For the best of both worlds, contact your local Bourns representative or send today for your new PC-1 Panel Controls catalog. See the 1979-80 EEM directory, Volume 2, pages 3754, 3755.

CONTROLS DIVISION, BOURNS, INC.,
1200 Columbia Avenue, Riverside, CA 92507
Phone: 714 781-5305 TWX: 910 332-1252

European Headquarters: Bourns AG, Zugerstrasse 74 6340 Baar, Switzerland. Phone: 042 33 33 33. Telex: 78722.



The last word in resistive components

BOURNS®

For Immediate Application—Circle 130 For Future Application—Circle 230

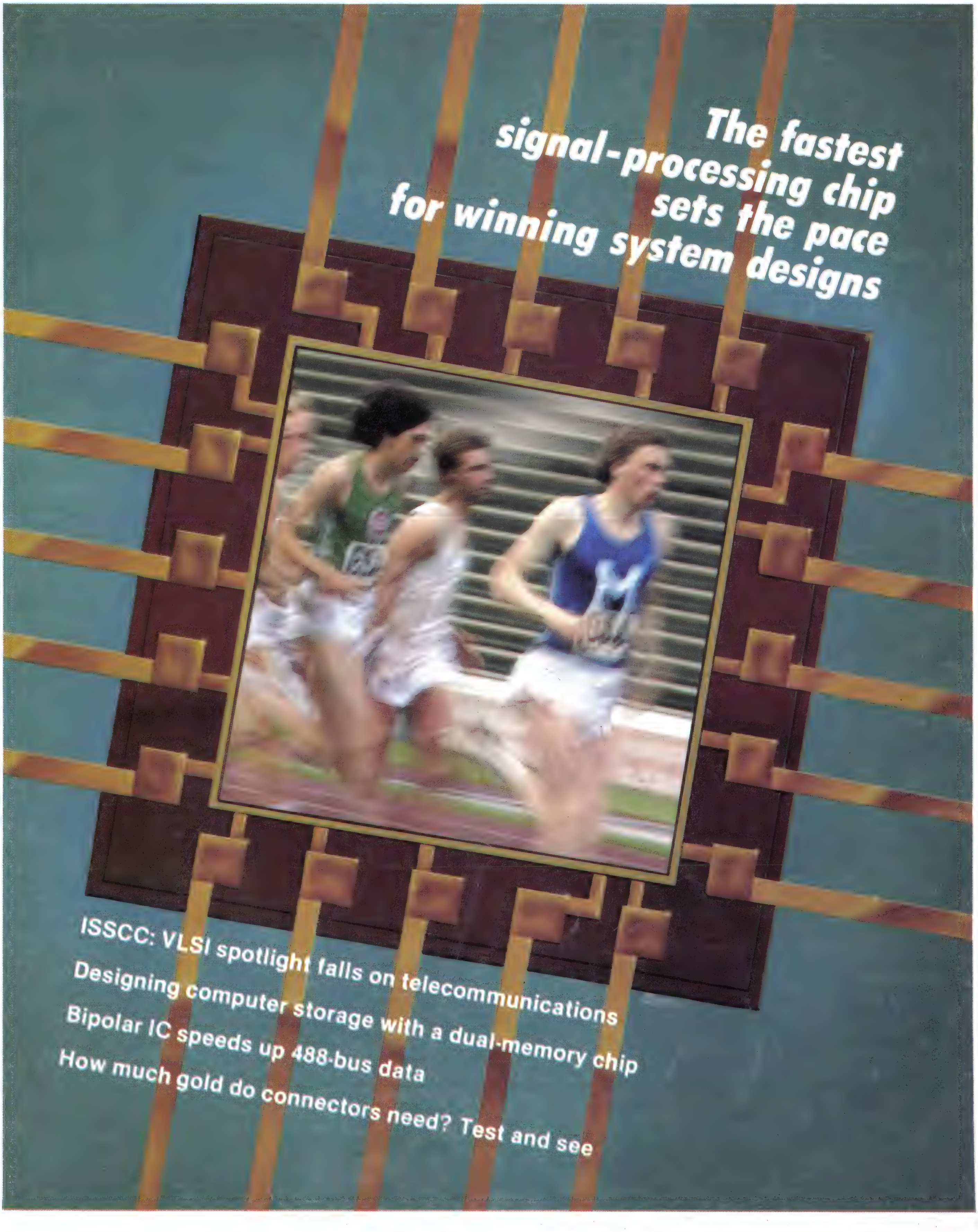
Electronic Design®

International Edition

VOL. 28 NO. 4

FOR ENGINEERS AND ENGINEERING MANAGERS — WORLDWIDE

FEB. 15, 1980



The fastest signal-processing chip sets the pace for winning system designs

ISSCC: VLSI spotlight falls on telecommunications

Designing computer storage with a dual-memory chip

Bipolar IC speeds up 488-bus data

How much gold do connectors need? Test and see

The Panasonic Dream Machine.

Selecting the right microcomputer for your product is tricky business. There are so many variables. Like the technology. What's available to fit your design requirements? With how many on-chip functions? How many instructions? How fast? How much memory?

Now there's one family of microcomputers with all the right answers. The Panasonic 4-bit MN1400 series.

Three technologies

Panasonic MN1400's are available as C-MOS, P-MOS and N-MOS to fit your specific design requirements. You can fit the right chip to your design.

	Model	Package	On Chip Memory	
			Instruction ROM	Data RAM
N-MOS	MN1400	40 Pin DIP/Plastic	1024 x 8 bits	64 x 4 bits
	MN1402	28 Pin DIP/Plastic	768 x 8 bits	32 x 4 bits
	MN1403	18 Pin DIP/Plastic	512 x 8 bits	16 x 4 bits
	MN1404	16 Pin DIP/Plastic	512 x 8 bits	16 x 4 bits
	MN1405	40 Pin DIP/Plastic	2048 x 8 bits	128 x 4 bits
	MN1498	40 Pin DIP/Plastic	External	64 x 4 bits
P-MOS	MN1430	40 Pin DIP/Plastic	1024 x 8 bits	64 x 4 bits
	MN1432	28 Pin DIP/Plastic	768 x 8 bits	32 x 4 bits
	MN1435	40 Pin DIP/Plastic	2048 x 8 bits	128 x 4 bits
C-MOS	MN1450	40 Pin DIP/Plastic	1024 x 8 bits	64 x 4 bits
	MN1453	18 Pin DIP/Plastic	512 x 8 bits	16 x 4 bits
	MN1454	16 Pin DIP/Plastic	512 x 8 bits	16 x 4 bits
	MN1455	40 Pin DIP/Plastic	2048 x 8 bits	128 x 4 bits

Varying computing power

The 12-strong MN1400 microcomputer family offers devices with varying amounts of computing power, so you can choose the chip that meets your specific requirements. And even if your memory needs change, you can substitute another model within the family and save your basic design. You pay only for the computing power you need.

They're all on the chip

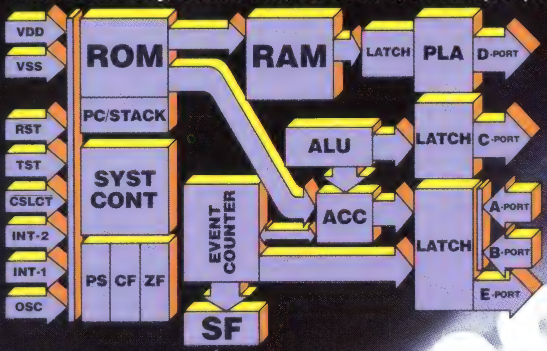
We put all these microcomputer functions on a single chip:

- ALU
- Up to 16,384 (2048 x 8) bit ROM
- Up to 512 bits (128 x 4) RAM
- Two 4-bit parallel input ports
- 4-bit parallel output port
- 8-bit output port with PLA
- With 12 discrete output lines
- 8-bit counter/timer
- Clock generator

Add to that the fast 10μs instruction speed and a powerful instruction set with up to 75 versatile instructions that let you computerize a variety of end products with ease.

And you needn't stop with design. Panasonic takes you from concept through production with software and hardware development tools: cross-assemblers, edit software and debugging and prototyping hardware, and, of course, fast turnaround in mask preparation.

So if on-chip capability has been giving you sleepless nights, take the Panasonic cure. For complete information and prices write to Panasonic Electronic Components, One Panasonic Way, Secaucus, NJ 07094; or call (201) 348-7269.



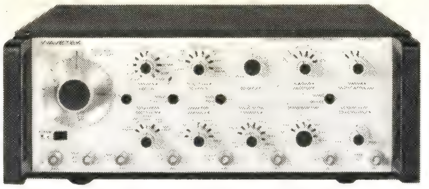
PMOS
CMOS
NMOS
The 4-bit microcomputer with three technologies and varying computing power
Panasonic®
just slightly ahead of our time

CIRCLE NUMBER 128

Some folks work in a digital world, with pulse generators. Others are functioning on the analog side.

So Wavetek has created the Model 166. A function generator with a pulse. A pulse generator with functions. Both go from 0.0001 Hz to 50 MHz.

The function generator has sweepable sine, square, triangle, ramp, and haverwave outputs. Plus a variety of trigger and



sweep modes.

The pulse generator includes sophisticated width and transition controls. Either generator can be amplitude and frequency modulated with an AC signal, or amplitude and frequency controlled with a remote DC signal.

But what if you're a third kind of person, and need both a pulse and a function generator? Then our $1695* price will look twice as good to you.

Wavetek, 9045 Balboa Avenue,
P.O. Box 651, San Diego, CA 92112.
Telephone: (714) 279-2200 TWX
910-335-2007.

WAVETEK®

*U.S. Price

CIRCLE NUMBER 2 FOR DEMONSTRATION

CIRCLE NUMBER 3 FOR LITERATURE

There are two kinds of people in the world.

They both need Model 166.

Now...1 watt output from your H-P generator!

0.04-1000 MHz from $199

Need more than the 10 mw available from your signal/sweep generator or synthesizer for system and subsystem testing?

Just add a MiniCircuits' ZHL wideband amplifier and boost the 10 mw level to 1 watt or +30 dBm. Also, there's an additional benefit ... as much as 40 dB isolation will be added between the generator and the system under test. And VSWR is less than 2:1 over the full frequency range.

Upgrade your present generator now ... check the specs and low prices below and order your ZHL wideband amplifier today ... and we will ship within one week!

MODEL NO.	FREQ. MHz	GAIN dB	GAIN FLATNESS dB	MAXIMUM POWER OUTPUT dBm 1-dB COMPRESSION	NOISE FIGURE dB	INTERCEPT POINT 3RD ORDER dBm	DC POWER		PRICE	
							VOLTAGE	CURRENT	$ EA.	QTY.
ZHL-1A	2-500	16 Min.	±1.0 Max.	+28 Min.	11 Typ.	+38 Typ.	+24V	0.6A	**199.00**	**(1.9)**
ZHL-2	10-1000	16 Min.	±1.0 Max.	+29 Min.	18 Typ.	+38 Typ.	+24V	0.6A	**349.00**	**(1.9)**
ZHL-3A	0.4-150	24 Min.	±1.0 Max.	29.5 Min.	11 Typ.	+38 Typ.	+24V	0.6A	**199.00**	**(1.9)**

Total safe input power +20 dBm, operating temperature 0° C to +60° C, storage temperature −55° C to +100° C, 50 ohm impedance, input and output VSWR 2:1 max. For detailed specs and curves, refer to 1979/80 MicroWaves Product Data Directory, p. 364-365 or EEM p. 2970-2971.

2625 East 14th Street Brooklyn, New York 11235 (212) 769-0200
Domestic and International Telex 125460 International Telex 620156

World's largest manufacturer of Double Balanced Mixers
Mini-Circuits
MINI-CIRCUITS LABORATORY
A Division of Scientific Components Corp.

R45/Orig.

CIRCLE NUMBER 4

Publisher:
Laurence Altman
Editor:
Lucinda Mattera
Executive Editors:
Stephen E. Scrupski
Stanley Runyon
Senior Editors:
David Bursky, Morris Grossman, Sidney Adlerstein
Technology Editors:
Analog Circuits & Components: Stephan Ohr
Circuit Design & Professional: Donald Mennie
Communications: Sidney Adlerstein
Computers & Peripherals: Leonard Yencharis
Instruments: Jonah McLeod (Sunnyvale)
Packaging & Power Sources: Morris Grossman
Semiconductors: David Bursky (Sunnyvale)
Software & Systems Integration: Max Schindler
Field Bureau Editors:
Eugene Heftman, New York
Ron Shinn, Los Angeles
New Products Editor:
Harold Winard
Copy Editors:
James Keane
Sharon Bailly
Production Editors:
Marjorie Duffy
Assistant, Edward Connolly
Art Director: William Kelly
Assistant Art Director: Anthony J. Fischetto
Illustrator: Thomas Blaine
Editorial Secretaries:
Jane Merkel, Mary James,
Jeanine Lawson, Faye Clarke

Business Manager:
Thomas E. Vachon
Administrative Assistant:
Susan G. Apolant
Executive Secretary:
Jerri Strasser
Advertising Production:
Manager, Edward J. Grimm
Paul InCalcatera, Frank Murphy, Sharon Roden
Circulation:
Director, Barbara Freundlich
Senior Assistant, Gail Stone
Reader Service:
Paula Greenleaf
Promotion:
Director, Robert Pavone
Manager, Jay McSherry
Reprints:
Maxine Sassano
Editorial Offices:
50 Essex St.
Rochelle Park, NJ 07662
(201) 843-0550
TWX: 710-990-5071
(HAYDENPUB ROPK)
Cable Haydenpubs Rochellepark
West Coast:
8939 S. Sepulveda Blvd., Suite 414
Los Angeles, CA 90045
(213) 641-6544
TWX-1-910-328-7240

1307 S. Mary Ave., Suite 212
Sunnyvale, CA 94087
(408) 736-6667

Electronic Design®

VOL. 28 NO. 4
FOR ENGINEERS AND ENGINEERING MANAGERS — WORLDWIDE
FEB. 15, 1980

News & Technology

23 **Bubble, RAM reliability** under study.
24 **Testing codecs** takes both analog and digital techniques.
25 **Gold-saving inlay process** improves connectors, semi lead frames.
26 **Power supplies aim for higher frequencies,** computer analysis.
28 **Handling power brownouts** in computer systems.
32a **International section**
41 **Special Report:** ISSCC ushers VLSI into the 80s.
43 **Digital:** RAMs and EPROMs pack more bits.
49 **Linear:** Converter circuits get easier to use.
57 **Telecommunications:** More functions for both ends of the link.
63 **Special-Purpose LSI:** CCDs, I^2L for general applications.

Design Engineering

86 **Programmable analog signal processor** sets speed records (cover).
91 **RAM and E^2PROM combine** on one TTL-compatible chip.
101 **Relieve μP overhead** with a DMA IC.
109 **Simplify IEEE-488 system peripheral-interfaces** with a bipolar chip.
118 **MC6801's eight operating modes** optimize the μC systems.
127 **Machine codes** compress instructions for the MC6801.
137 **Programmable signal processor LSI** rivals analog filters.
145 **No-gold connectors** give top performance—with testing.
152 **Ideas for Design:**
Back-emf sensing circuit makes its own motor into tachometer.
BiMOS control chip extends battery life of camera's photoflash.
Low-battery threshold detector draws 2 μA standby.
Two-IC temp-sensor probe converts DMM to digital thermometer.

New Products

163 **Instruments:** Logic-state indicator monitors 40 test points.
165 New temperature scanner is accurate, inexpensive.
176 **Packaging & Production:** Cable connector latches onto boards.
178 Ultrasonics detect, locate and predict valve leaks.
189 **Analog Circuits:** 10-bit DAC features fast input latches.
190 Driver/amp for power MOSFETs does it all on one chip.
192 Display drivers combine ASCII decoder and 18-segment drive.
194 Modular a/d converters include sample/hold circuits.
198 **Communications:** Hybrid receiver/amplifier eases data comm.
206 **Components:** Molded-to-spec elastomer keyboard cuts parts cost.
214 **Materials:** Reinforced plastic resists heat, impact.
216 Peripherals
220 Subassemblies
222 Computers
223 Microsystems
225 New Literature
229 Vendors Report
231 **Management:** How Motorola's Al Stein remade its LSI future.

Departments

11 Reader Feedback
19 News & Technology Previews
68 Editorial
77 From Washington
234 Employment Opportunities
257 Advertisers' Index
258 Reader Service Card

119,148 copies of this issue printed.

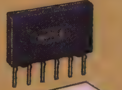
ELECTRONIC DESIGN (USPS-172-080) is published biweekly except 3 issues in July by Hayden Publishing Company, Inc., 50 Essex St., Rochelle Park, NJ 07662. James S. Mulholland Jr., President. Printed at Brown Printing Co., Waseca, MN. Controlled circulation postage paid at Waseca, MN, and New York, NY. Postage pending Rochelle Park, NJ. Copyright© 1980 Hayden Publishing Company, Inc. All rights reserved. POSTMASTER: Please send form 3579 to ELECTRONIC DESIGN, P.O. Box 13803, Philadelphia, PA 19101.

First with the most Mil-style networks

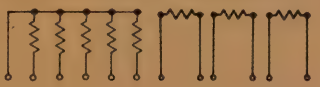
...it's what you'd expect from Dale!

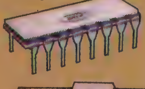
DIP, SIP, flat pack and chip. Dale has more ways you can take advantage of thick film resistor technology in military applications. Choose the space-saving reliability of our MSM, SDM or DFM networks. All are qualified to MIL-R-83401 and all are available in your choice of isolated resistor or one pin common schematics. Order now for shipment from our stock of popular resistance values. Or use our RC chip resistors to add design flexibility to your hybrid circuitry. Being first with the most Mil networks is just the beginning of the ways Dale is qualifying to serve you. Ask for our complete catalog of thick film networks.

MIL-R-83401: All Dale Mil-qualified networks offer isolated resistor schematics commonly used for pull-up, pull-down, balancing and line termination. Both DIP and SIP models also provide one pin common schematics for the same application.



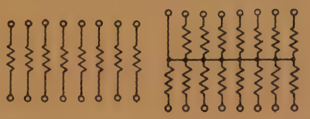
MSM (RZ040, RZ050)
6 and 8 pin SIP





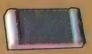
SDM (RZ010, RZ020)
14 and 16 pin DIP

DFM (RZ030)
14 pin flat pack



MIL-R-55342/4: Chip resistors with choice of single side or wrap-around terminations. Resistance range: 10 ohms to 1 Megohm. Power: 350 MW. T.C. ±200 PPM.

RCM
(RM1505)



DEPENDABLE
DALE®

Contact your Dale Representative or Phone 402-371-0080 today.

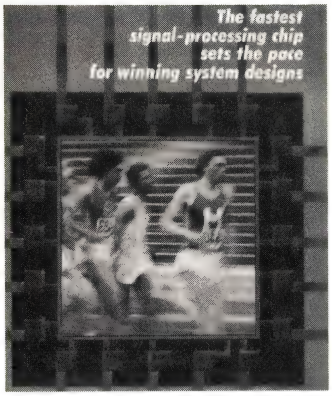
DALE ELECTRONICS, INC., Box 74, Norfolk, NE 68701 • *A subsidiary of The Lionel Corporation*

CIRCLE NUMBER 5

Contents Spotlight

Special Report: ISSCC ushers VLSI into the 1980s
VLSI is pushing RAMs and EPROMs to the 64-kbit level and even beyond, but that's just part of the story at this year's International Solid State Circuits Conference. Specialized circuits are making their presence felt in many diverse applications, including telecommunications, data-acquisition and even medical and consumer. ISSCC as a whole is pretty special—it's the one conference that keeps pace with the yearly advances in the semiconductor art, not only here but around the world.

p. 41

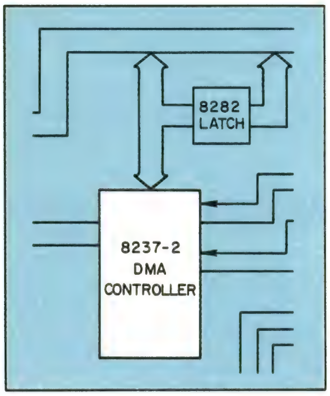


Analog signal processor breaks speed records
Process technology and architecture hit the right combination in a programmable analog processor that can multiply two 16-bit numbers on-chip faster than any other LSI processor. This means that sampling rate—important in voice encoding applications—can be given a significant boost. Find out the first details.

p. 86

Turn off the power on this RAM—it's nonvolatile
For the first time, designers can enjoy the benefits of nonvolatility in a high speed RAM. A new chip combines a 1-kbit RAM with an electrically erasable 1-k PROM. Data can be transferred back and forth whenever desired between the two on-chip memories. Once the data are in RAM, they can be manipulated or changed as in any other RAM. A copy of the original data remains unaltered in the nonvolatile section of the chip. Learn how to build the two-memory IC into a computer system.

p. 91



Off-loading a microprocessor with a DMA chip
With interactions taking place between peripherals and memory, one way to speed up a μP is to take it out of the system. How? By calling upon a new direct-memory-access chip to perform the high-speed data transfer. Operating at the fast clock speeds of the latest μPs should open the door to using speedier peripherals, including multi-Mbit disk with fiber-optic links.

p. 101

The New Generation of Custom Monolithic Hybrid Converters from DDC.

By using customized monolithic chips, DDC has taken a giant step forward in converter technology. The new product—Monobrid—is much smaller, less complex, more reliable and requires less power than conventional hybrids.

The first of DDC's new Monobrid series is a *single* 36-pin DDIP module containing a complete 14-bit S/D or R/D converter. At half the size of conventional hybrids the new DDC-8915 Series Monobrid packs the same kind of high performance. Accurate to ±2.6 minutes, the new S/D Monobrid offers tri-state latched outputs in two bytes and continuous tracking, even during data transfer. It accepts broadband inputs of 360 to 1000 Hz, or 47 to 1000 Hz; and is made to order for applications where small size, high MTBF and low power are critical.

For more information about DDC's new 8915 Series Monobrid converter, call or write Department B-1, today.

DDC™

ILC DATA DEVICE CORPORATION
Dept. B-1, 105 Wilbur Place, Bohemia, New York 11716
516•567•5600, TWX: 510•228•7324

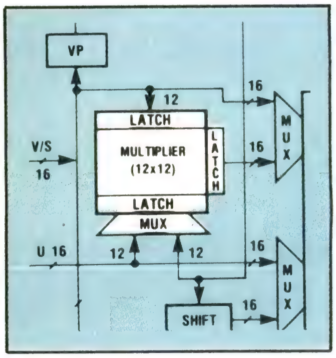
LOS ANGELES: ILC Data Device Corporation, Dept. B-1, 7337 Greenbush Avenue, No. Hollywood, CA 91605 (213) 982-6454. TWX 910-499-2674; **LONDON:** DDC United Kingdom Ltd., Dept. B-1, 128 High Street, Hungerford, Berkshire RG17 ODL, England (44) 4886-2141/2142, TLX 851-848826; **PARIS:** DDC Electronique, Dept. B-1, 4 Rue De Abreuvoir, 92400 Courbevoie, France (01) 333-5888, TLX 842-630609

Note: Monobrid™ is a trademark of ILC Data Device Corporation

CIRCLE NUMBER 6

Bipolar IC gets top performance from IEEE-488 bus
Right now, equipment connected along the IEEE-488 standard bus can communicate and move data along at a maximum rate of 1 Mbyte/s. While that speed suffices for many measurement systems, reaching that level is not that simple. A bipolar IC helps get the top rate by performing both talker and listener functions on the bus.

p. 109



Signal processing simplifies digital filters
Specialized programmable signal-processing LSI chips are appearing in increasing numbers on the design scene. One major reason is the ease with which complex digital filters can be put together using software programs as the glue. Get acquainted with one LSI processor, and see how to design filters that can sample as fast as 100 kHz.

p. 137

Gold in connectors—less is more
With gold prices threatening to climb out of sight, designers have all the incentive they need to minimize its use in connectors. But how much gold is enough? Specification tips and performance tests answer the question.

p. 145

Electronic Design 5

Featured Next Issue

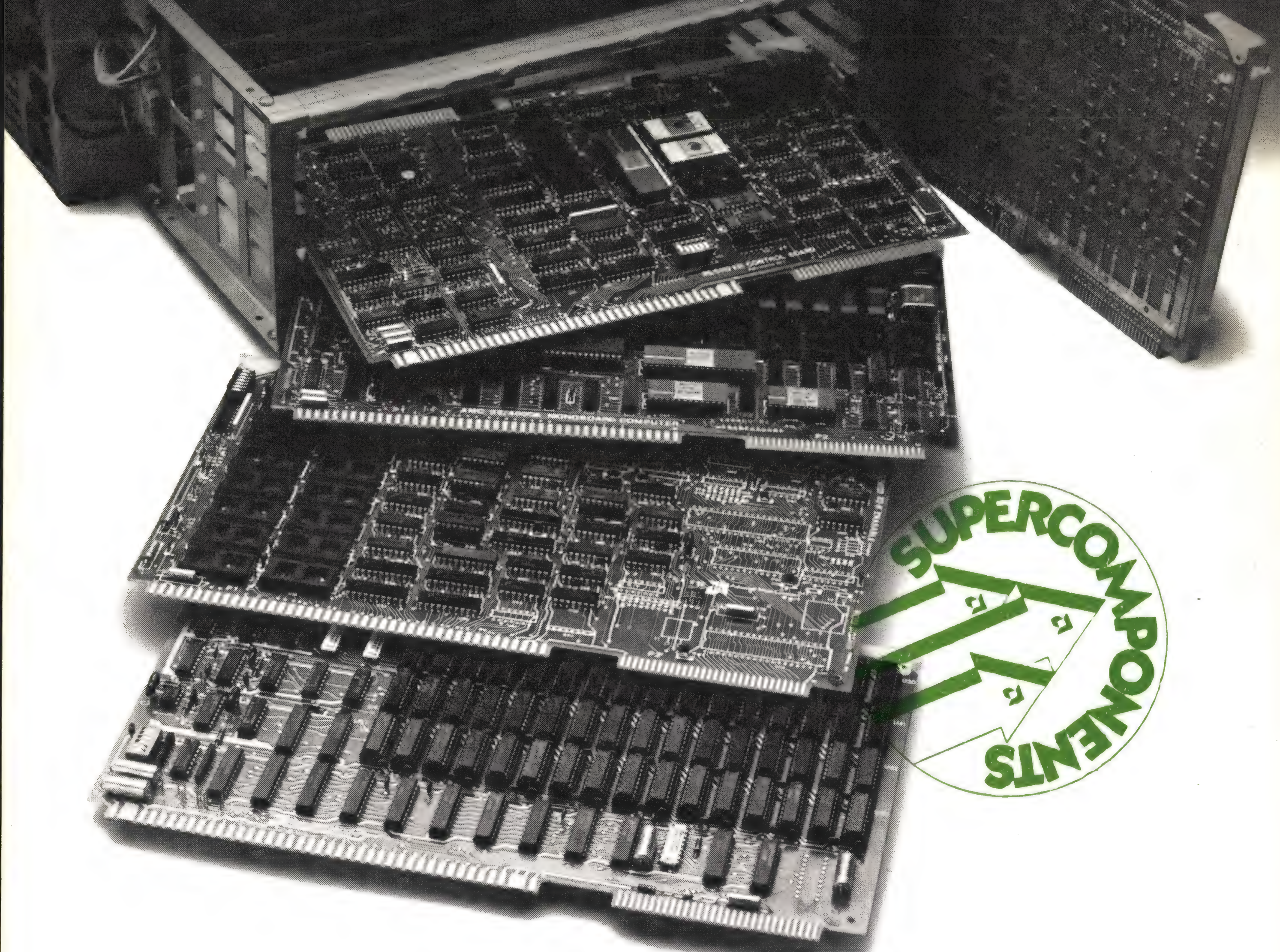
In the March 1 issue:

Interface '80: Data communications goes OEM . . . Focus on Capacitors: Materials are the key to specifying . . . 16-bit Slave Processor does floating-point arithmetic . . . Optical fibers replace wires in computer systems . . . Selecting components for 200-kHz switchers.

A process-control engineer wants a high-speed, low-cost computer to monitor and control a factory operation. He checks out the Supercomponent™ specs and moves on to the next project. This job's done.

A systems engineer is designing a blood analyzer on a really tight schedule. He needs a digital controller to record, analyze, compare, file and retrieve data. He reviews the Supercomponent technical manual, then moves on. The job's done.

A systems designer wants to control a radar telemetry system. There are special software considerations, and real-time data is needed. (Last year, a design just like it took him six months.) He spends a couple days with Supercomponent specifications and moves on. The job's done.



Here come the Supercomponents!

Advanced Micro Devices announces a family of LSI-intensive boards built to save the serious systems designer a whole lot of time and money. Supercomponents are changing the make-or-buy rules. Here's why:

They're absolutely state of the art. They are designed-in like components and they think like VLSI. They save you a ton of interface design time. They're plug-in ready. All are iSBC80* compatible and have a Multibus.* And, of course, we have all the enclosures and power supplies and card cages and back planes and software you need to cut your costs and accelerate your project.

Now for the big reason: Supercomponents are better because the parts are better. They're made from the finest, freshest, most advanced LSI in the business.

You picked a terrific time to be in this business. Supercomponents are here.

The Am95/4005.

Our single-board computer, The Monoboard,™ is very powerful. It has all the features others in its class have, but—over and above—it includes a sophisticated arithmetic processor, four DMA channels and speeds up to 3 megahertz!

The Am95/6110.

Our floppy disk controller has its own built-in intelligence. It has its own Am8085A CPU plus a high-speed buffer and its own PROM-based firmware. A DMA is included. There's much more. You'll have to read the full specs to believe it.

The Am95/1128.

128K bytes of RAM on a board plus parity with its own built-in refresh. The RAM can be dual-ported. Smaller capacities can be achieved by depopulating the board. The Am95/1128 has twice the capacity of its nearest competitor.

These are just a few members of our Supercomponent family. Call or write us for the facts on all of them.

*iSBC and Multibus are trademarks of Intel Corp.

Advanced Micro Devices

901 Thompson Place, Sunnyvale, CA 94086

2/15/80

Advanced Micro Devices
Mail Operations, P.O. Box 4
Westbury-on-Trym, Bristol BS9 3DS
United Kingdom

Your Supercomponents sound really super. Send me all the facts.

Personal Name____________________

Personal Title____________________

Company Name____________________

Town (with postcode)____________________

Country____________________

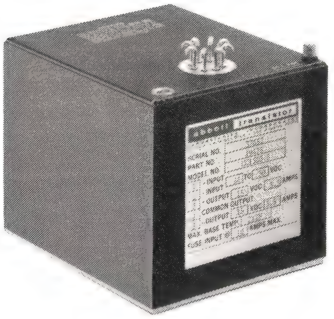
Advanced Micro Devices • France: European Marketing Centre, 27, Boulevard Général-Vautrin, 06400 Cannes, France, Tel: (093) 48.59.75. Silic 314, Immeuble Helsinki, 74, rue d'Arcueil, 94588 Rungis Cedex, France, Tel: (01) 686.91.86. **Belgium:** Avenue de Tervueren, 412, bte 9, 1150 Bruxelles, Belgium, Tel: (02) 771.99.93. **Germany:** Rosenheimer Str. 139, 8 Muenchen 80, West Germany, Tel: (089) 40 19 76. **Italy:** Centro Direzionale, Palazzo Vasari, 3rd Floor, 20090 Milano 2, Italy. Tel: (02) 21.39.020. **United Kingdom:** 16 Grosvenor Place, London SW1X 7HH, England, Tel: (01) 235-6388.

abbott POWER SUPPLIES

Fit for land, sea and air.

For over 15 years Abbott power supplies have seen service with every branch of the military . . . from the XM-1 tank to the Trident submarine to NASA's SKYLAB. Proven performance in these and other critical military and aerospace applications is the result of Abbott's unique capabilities and experience in power supply design.

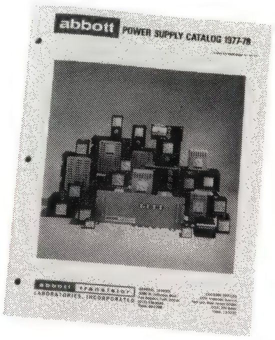
The Model "W" family, for example, because of its unique combination of laboratory-type performance and aerospace size, has become a standard throughout the world. Over 10,000 units are in service, featuring output voltages from 5 to 100 VDC, with current levels from 0.3 to 20 amps . . . in packages as small as 2⅛" x 3¼" x 3¼".



Today, Abbott offers a choice of over 1500 versions of high efficiency, hermetically sealed, single or dual output power supplies and switcher modules. They include 60 and 400Hz to DC modules, DC to DC converters, and DC to AC inverters, with outputs from 3 VDC to 740 VDC, 1 to 250 watts. And prices are as low as $174 for 2-4 units.

So, for quality, reliability, performance and low cost, call Abbott. As for delivery, we can probably ship from stock. For additional information, see your EEM or GOLD BOOK power supply sections, or write us for a free catalog.

See Power Supply Section 4000, and Transformer Section 5600, Vol. 2, of your EEM catalog; or Power Supply Section 4500, and Transformer Section 0400, Vol. 2, of your GOLD BOOK for complete information on Abbott products.



abbott transistor

LABORATORIES, INCORPORATED

General Offices
5200 W. Jefferson Blvd., Los Angeles, CA 90016
(213) 936-8185 Telex: 69-1398

Eastern Offices
1224 Anderson Ave., Fort Lee, NJ 07024
(201) 224-6900 Telex: 13-5332

CIRCLE NUMBER 7

Reader Feedback

State-of-the-art junk?

Your special Microprocessor Issue (Nov. 22, 1979) was well done—it shows the junk some manufacturers are making in the name of state of the art:

- With too much emphasis on retaining software compatibility, they have neglected the need for redesigning a more flexible and efficient 8-bit processor to be used where a 16-bit machine is not required.
- In dedicated systems for scientific instruments, there is a great need for fast bit tests, implicit branches, implicit register-encoding and decoding instructions, along with the normal data processing requirements. All this could easily be realized using internal CPU microprogrammable routines. So far only Advanced Micro Devices comes close with the Am29116.

Another thing: Over in News & Technology Previews (p. 22), you describe iridium as a white, metallic chemical. It is neither white nor chemical. It is the heaviest and the most inert of *all* metals, and has an elasticity modulus of 75-million lb/in.^{2} as well as an extremely high melting point of 4429 F.

John Rustenburg

Brock University
Glenridge Campus
St. Catharines, Ontario, Canada

Look ahead did not look far enough

In your article "Minis Look Ahead" (Jan. 4, 1980, p. 98), you refer to the Harris Slash-7 computer with its 0.77-Mbyte main-memory capacity. About a year ago, Harris began marketing the Series-500 minicomputers, which can access more than 2 Mbits of MOS main memory in just 290 ns. The Series-500 also features a virtual memory of more than 12 Mbytes, a 300-ns microcyle, MOS-memory error correction, a bipolar microprocessor and a central dual-word bus system.

We at Harris SAI have been using a Harris 550 computer since last July for scientific applications and have found its speed to exceed that of the old IBM 360/67 mainframe.

Paul F. McGuire
Engineering Manager

Harris SAI, Inc.
611 Church St.
Ann Arbor, MI 48104

Recognition due

We work, we slave, we produce some of the niftiest products on the market and we still can't get the recognition we deserve. Specifically, in your Nov. 22, 1979, issue (p. 126), you list AMD as the alternate source for two DMA controllers when it really should be the other way around.

The Am9517 has been on the market for over a year and Intel's 8237 is built under a cross-license agreement. They use our masks. The Z8016 is also an AMD design. It is part of our agreement with Zilog for AMD to build half the peripheral support chips. Please let your readers know the real scoop.

Robert M. Grossman
Public Relations Manager

Advanced Micro Devices Inc.
901 Thompson Pl.
Sunnyvale, CA 94086

'Write' could be wrong

Thank you for the important message in your editorial, "The 'Write' of Leadership" (Dec. 6, 1979, p. 47).

As I understand it, the top manufacturer in terms of first announcement or highest sales or best known should not be considered more likely to be the best supplier of the product of choice.

(continued on page 14)

Electronic Design welcomes the opinions of its readers on the issues raised in the magazine's editorial columns. Address letters to Editor, Electronic Design, 50 Essex St., Rochelle Park, NJ 07662. Try to keep letters under 200 words. Letters must be signed. Names will be withheld upon request.

JANCO ROTARY SWITCHES
offer SIMPLE solutions to complex switching problems!

P-C Rotary Switches
"THE MIGHTY MINIATURE"
Optimum simplicity! Features the sophisticated circuitry of a coded switch plus all the advantages of a sealed rotary . . . and it's only .6" in diameter and .5" deep (from mounting face to the base of the pin terminals). Mounting is simpler! Wiring is simpler! Available in 8, 10, 12 positions. 1" diameter is available in up to 24 positions.

PUSH-BUTTON Rotary Switches
Unique in design by virtue of their simplicity, these Janco rotary switches also function accurately and quickly in the most adverse environmental conditions. Can be "ganged" together for high density packaging. Available in bi-directional and uni-directional in 8, 10, 12, 16 positions with codes galore!
MIL SPEC QPL
Mil-S-3786 & Mil-S-22710

Rotary Selector Switches
Standard rotary selector switches, power, miniature, micro-miniature, solenoid operated, keylock, momentary, etc. . . . Janco has the rotary switch for your application. Proof is in the usage! Almost every military and commercial craft that flies has been using Janco rotary switches **for over 30 years!**

Janco CORPORATION
3111 Winona Ave., Burbank, CA. 91504
Phone (213) 846-1800 • TWX 910-498-2701

CIRCLE NUMBER 8

Sure Winners

Competitive systems start with Intel® static RAMs. Now you can choose a champion for any design.

High performance memory design is a fast track. The winners are those who match advanced components precisely with today's system requirements. When it comes to static memory, only one supplier has the broad selection of high speed, low power RAMs, and the delivery you need to bring your product to market ahead of the field.

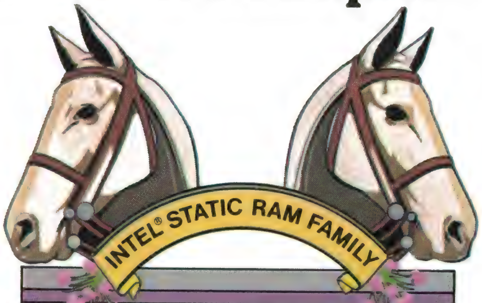
Over 50 Purebred RAMs

From the beginning, Intel has been the leader in practical, producible MOS memory technology. First NMOS. Then high performance HMOS,* the high reliability technology that's produced more than 14 million fast static RAMs —as well as our industry standard 16-bit microcomputer, the 8086. Now HMOS II* is here, bringing you the same reliability and a new generation of even higher speed static RAMs.

Today, Intel gives designers the widest selection of 1K and 4K static RAMs in the industry. Over 50 different versions let you tailor speed, power, density and organization precisely to your system requirements.

Record breakers for high speed systems

Nowhere is the precision matching of memory components to function more important than in high speed cache, buffer, control store and main memory. At Intel, you'll find static RAMs to cover your full range of design goals.



SPEED (ns)	1K x 1	4K x 1	1K x 4
20	2115H/25H (20-35ns)	2147H (35-55ns)	2149H* (45-55ns)
40			
60	2115A/25A (45-70ns)	2147 (55-85ns)	2148H* (45-55ns)
80			2148 (55-85ns)
100			
200		2141 (120-250ns)	2114A (120-250ns)
300			

*Available Q1, 1980

For highest speed and low power, no bipolar can touch our HMOS II 2115H/25H 1K static RAMs. One version gives you record access times of 20ns; three others let you choose speed/power combinations to 35ns. For designs requiring speeds from 45-70ns, our 16-pin industry standard HMOS 2115A/25A series covers the spectrum. All of these 1Ks are pin-compatible replacements for 93415/25 bipolars, and all give you dramatically lower power, too.

In a 4Kx1 format, our HMOS 2147 is the industry standard for low power and speeds to 55ns. Today, designers requiring even higher performance will find a winner in our new HMOS II 2147H—with versions as fast as 35ns and standby power dissipation of only 30mA.

Finally, for special wide-word memories, including control store and bit slice designs, Intel's 1Kx4 bit 2148 is out in front. It gives you all the performance advantages of the HMOS 2147, plus the modularity that lets you save 75% on board space compared with 1K designs. And, you can expect even faster speeds in the future as we apply HMOS II to wide-word memory devices.

Pick the best performer for microcomputers

For years, microcomputer system designers have relied on Intel's 18-pin industry standard 2114 static RAM in 1Kx4 designs. Now we've used HMOS technology to improve performance with our new 2114A. It's a direct descendent of our 2114, but with a 30% smaller die size, 40% faster speeds, and 43% less power dissipation. The 2114A gives you performance equal to that of our 4Kx1 bit 2141, so you get optimum efficiency no matter what modularity you need—no matter how basic or how advanced your microcomputer application.

Intel gets you off and running now

We're delivering all of these fast static RAMs today. To order, or for more information, including our HMOS Reliability Report, RR18, contact your local Intel sales office or distributor. Or write Intel Corporation, Literature Department, 3065 Bowers Avenue, Santa Clara, CA 95051.

intel® delivers.

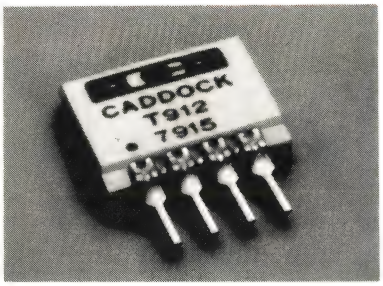
Europe: Intel International, Brussels, Belgium. Japan: Intel Japan, Tokyo. United States and Canadian distributors: Arrow Electronics, Alliance, Almac/Stroum, Component Specialties, Cramer, Hamilton/Avnet, Harvey, Industrial Components, Pioneer, Wyle/Elmar, Wyle/Liberty, L.A. Varah and Zentronics.

---

*HMOS and HMOS II are patented processes of Intel Corporation.

CIRCLE NUMBER 9

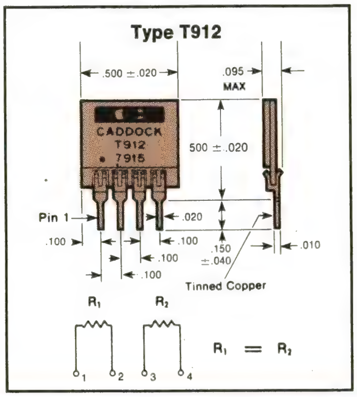
Precision Resistance Ratios from Caddock.



Caddock's Type T912 Precision Resistor Network is the cost-effective replacement for discrete resistor sets.

The ratio characteristics of these high-stability resistor networks make them ideal for applications in precision amplifier circuits, voltage reference circuits and precision bridge circuits.

- **Ratio Tolerances from ±0.1% to ±0.01%.**
- **Ratio Temperature Coefficients of 10 PPM/° C, 5 PPM/° C or 2 PPM/° C.**
- **Ratio Stability of Resistance at Full Load for 2000 Hours within ±0.01%.**



Tetrinox™ — Caddock's unique high-resistance film — provides resistance values from 5 kohm to 2 Megohms in this package size.

Custom models with unequal values can provide resistance ratios as high as 250:1 and values from 1 kohm to 2 Megohms.

Standard Type T912 and T914 Precision Resistor Networks

Standard Resistance Values:

5K	50K	500K
10K	100K	1 Meg.
20K	200K	
25K	250K	
40K	400K	

Special or mixed resistance values are available as custom networks.

Ratio Tolerance:
Maximum ratio difference between any two resistors in the network.

-100 = 0.10%
-050 = 0.05%
-020 = 0.02%
-010 = 0.01%

Ratio Temperature Track:
Ratio Temperature Coefficient between any two resistors in the network from 0°C to +70°C.

-10 = 10 PPM/°C
-05 = 5 PPM/°C
-02 = 2 PPM/°C

Ordering Information:

To specify any of the standard Type T912 and T914 resistor networks, use this model number.

T912 - 500K - 010 - 02

Model No.
Resistance Value*
Ratio Tolerance*
Ratio Temperature Track*

* (This information appears on the back side of the network)

The standard models of Type T912 resistor pairs and Type T914 resistor quads can be delivered in prototype and production quantities from stock to within 6 weeks ARO.

For additional technical information — and immediate confirmation of price and delivery on initial quantities — call or write directly to:

Caddock Electronics, Inc.,
3127 Chicago Ave., Riverside, Calif. 92507
Tel: (714) 683-5361

CADDOCK
HIGH PERFORMANCE FILM RESISTORS

CIRCLE NUMBER 10

Reader Feedback

(continued from page 11)

A rational engineer, whether in purchasing, design, sales or production, appreciates performance, reliability, quality, price and supplier integrity. Often he looks for other qualifiers such as delivery, versatility and multiple sourcing when selecting a product.

Companies that publish more frequently and have a higher market share and flashy advertisements might make superior products—or they might not.

Robert Neidorff

3111 N. Los Altos Dr.
Chandler, AZ 85224

Minor changes

I found the article titled "Speed Ferromagnetic Inductor Designs with a Programmable Calculator" (Dec. 20, 1979, p. 74) to be informative and quite useful. However, after keying the program into my HP-67, I was unable to get the correct answer for d_e using the sample variables. After much thought (and hair pulling), I found that changing statement number 016 (p. 76) to f LN (31 52) produced the correct d_e.

Another minor change: When I initially loaded the program, I found the wire size displayed to two decimal places. This situation can be corrected by changing statement 164 to DSP 0 (23 00).

John W. Hafer
Senior Engineer

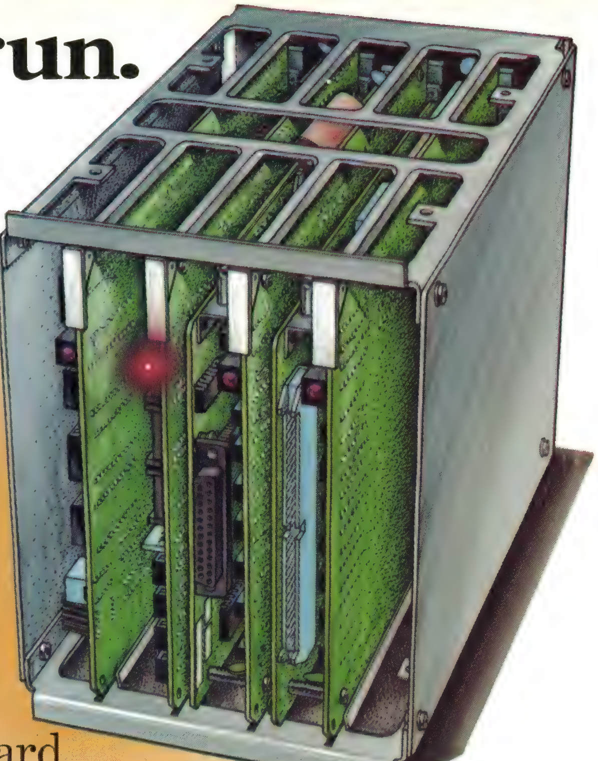
General Dynamics
Electronics Div.
P.O. Box 81127, M.S. 7-61
San Diego, CA 92138

Ed. Note: Thank you for the corrections. And thank you to Donald Beaty, of the Dept. of Telecommunications at the College of San Mateo (San Mateo, CA), for also calling our attention to statement 016.

An error in table banners

The title of the table on p. 66 in the article "Bilingual, 16-bit μP Summons Large-scale Computer Power" (Jan. 18, 1980) should read: "Table 1. Comparison of NS16000 family processors." The title of the table on p. 67 should be: "Table 2. Comparison of instruction and data types."

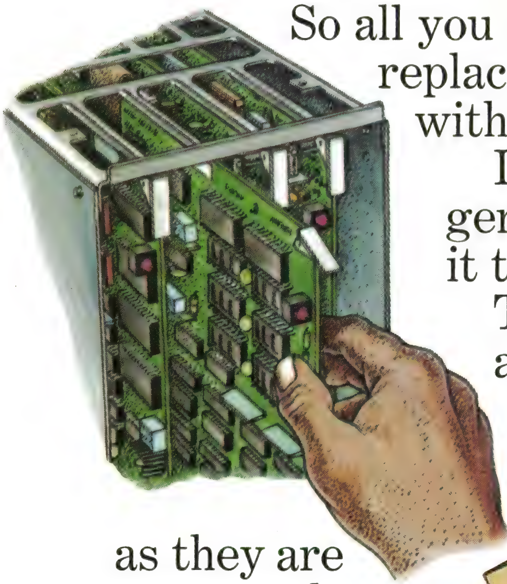
Run SCOUT,™ run.



Oh, oh! See the red light? It means SCOUT™ does not feel good. That can sometimes happen with minicomputers.

Oh, dear. This will cost a bundle to fix, won't it?

No, no. SCOUT has ISOLITE.™ It lights a red light to tell which board is bad. Bad board!



So all you do is replace the board with a spare quarter card.

It does not take a computer genius to make SCOUT run again. All it takes is three minutes.

Think how much money the OEM and the end user will save!

Are you an OEM or an end user?

You should buy lots of SCOUTS as they are very good.

Also, they are a very good deal. Under $1000 for CPU, I/O, 32K RAM and card cage. And with ISOLITE, your system is up more, so you get more run for your money.

Run SCOUT, run.

SCOUT AND ISOLITE are registered trademarks of Computer Automation, Inc.

A Plug for SCOUT.

See SCOUT run.

And save more time and money than you ever imagined. It's all in our how-to-save-on-maintenance primer. Get your free copy with this coupon and a business card. Or, for immediate information, call 714/833-8830, Ext. 455.

Name Title

Company

Address

City State Zip

ComputerAutomation
NAKED MINI® Division
Where OEM's come first.

18651 Von Karman, Irvine, CA 92713

Low-cost hard disk computers are here and field proven

11 megabytes of hard disk and 64 kilobytes of fast RAM in a Z80A computer for under $10K. Two floppy drives, too. Naturally, it's from Cromemco.

It's a reality. In Cromemco's new Model Z-2H you get all of the above and even more. With Cromemco you get it all.

In this new Model Z-2H you get not only a large-storage Winchester hard disk drive but also two floppy disk drives. In the hard disk drive you get unprecedented storage capacity at this price—11 megabytes unformatted.

You get speed—both in the 4 MHz Z80A microprocessor and in the fast 64K RAM which has a chip access time of only 150 nanoseconds. You get speed in the computer minimum instruction execution time of 1 microsecond. You get speed in the hard disk transfer rate of 5.6 megabits/sec.

EXPANDABILITY

You get expandability, too. The high-speed RAM can be expanded to 512 kilobytes if you wish.

And the computer has a full 12-slot card cage you can use for additional RAM and interface cards.

BROADEST SOFTWARE SUPPORT

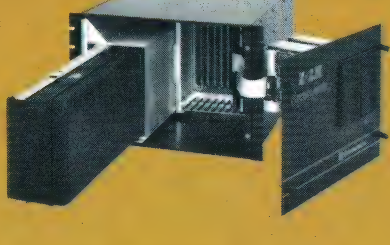
With the Z-2H you also get the broadest software support in the microcomputer field. Software Cromemco is known for. Software like this:

- **Extended BASIC**
- **FORTRAN IV**
- **RATFOR (RATional FORtran)**
- **COBOL**
- **Z80 Macro Assembler**
- **Word Processing System**
- **Data Base Management**

with more coming all the time.

SMALL, RUGGED, RELIABLE

With all its features the new Z-2H, including its hard disk drive, is still housed in just one compact cabinet.



Hard disk drive at lower left can be interchanged just by sliding out and disconnecting plug. Seven free card slots are available. Z-2H includes printer interface card.

Included in that cabinet, too, is Cromemco ruggedness and reliability. Cromemco is time-proved. Our equipment is a survey winner for reliability. Of course, there's Cromemco's all-metal cabinet. Rugged, solid. And, there's the heavy-duty power supply (30A @ 8V, 15A @ +18 V, and 15A @ −18V) for circuitry you'll sooner or later want to plug into those free card slots.

SEE IT NOW

Last summer we told you this new Z-2H would be a smash. And it is. So see it at your dealer's now. Have him put you in touch with a user—there are lots of them because Cromemco has been delivering for months. See for yourself how pleased our users are.

PRESENT CROMEMCO USERS

We've kept you in mind, too. Ask about the new Model HDD Disk Drive which can combine with your present Cromemco computer to give you up to 22 megabytes of disk storage.

Cromemco
incorporated
280 BERNARDO AVE., MOUNTAIN VIEW, CA 94040 • (415) 964-7400
Tomorrow's computers today
CIRCLE NUMBER 12

WE MAKE
TAPE DRIVES
FOR ALL REASONS

PDP-11
LSI-11
RS-232
NOVA
ROLM
NTDS

JUST PLUG IN
YOUR SYSTEM

We make a great family of tape drives and storage systems—From OEM building blocks to complete tape memory systems—For commercial, military and severe environment applications—Formatters and interfaces for RS-232, PDP-11, LSI-11, NOVA, ROLM and NTDS.

MODEL 200, a super compact MINIDRIVE™ for DC 100 data cartridge—Model 650, patented commercial tape drive for DC 300 data cartridge—Model 1200, a new modular tape storage system—Model 2200, rack mountable storage system—Model 2710, portable data loader/logger—Models 660, 3400, and 5100, rugged, military and severe environment drives and storage systems—Model TDX, a uniquely reliable 75 ips, IBM compatible tape drive.

Contact us today, we'll do the rest —

Qantex

Division of
North Atlantic Industries
60 Plant Avenue, Hauppauge, NY 11787
(516) 582-6060 TWX 510-227-9660

CIRCLE NUMBER 13

This is an offer you shouldn't resist. To introduce you to the new family of oscilloscopes from B&K-PRECISION, we'll let you "live with" one for up to 10 days, free! We're confident that after trying any one of our new scopes, you'll want to keep it for a lot longer. Of course, there's no obligation.

Leading off our 1400 series scopes is the new 1479, 30MHz dual-trace triggered scope. It's ready to challenge your testing needs with 5 mV/cm vertical sensitivity, 11.7 nS rise time, 50MHz triggering and built in high- and low-pass filters. A signal-delay line is built in to permit view of the leading edge of high frequency pulses. The 1479 also provides differential input capability and algebraic addition and subtraction of input signals.

For those requiring only a 15MHz dual-trace scope, the 1477 is an outstanding solution. Having many of the features of the 1479, the 1477 also offers a standard video sync separator for use with video systems or computer terminals. If battery portability is essential, the B&K-PRECISION 15MHz 1432 is a field-proven workhorse. It's a full-featured 3″, dual-trace scope with an optional battery pack. For a 10MHz response, choose either the dual-trac
or the single-trace 1466. For basic
monitoring applications, the low c
3″ 1405 is the best answer.

Common features of all 5″ 1400
scopes include Z-axis inputs, plug-
board construction, scope camera-
compatible CRT bezels, triggered s
excellent high- and low-voltage po
supply regulation, built in calibrati
signals and cool, energy-efficient o
tion.

For details contact B&K-PRECI
or your local distributor:
Germany 02-104-31147, France 54-37-
United Kingdom 0602-302331, Switze
01-820-57-47, Belgium 02-672-8400,
Holland 090-415547, Finland 919-1207
Denmark 03-28-38-41, Norway 034-8
Sweden 08-54-19-80.

Write for free 12-page color brochu

CIRCLE NO. 14 FOR ADDITIONAL INFORMATION
CIRCLE NO. 45 FOR FREE DEMONSTRATION

B+K PRECISION DYNASCAN CORPORATION

International Sales, 6460 W. Cortland Street • Chicago, IL 60635 USA • 312/889-9087 • TWX: 25-3475

Before you look at another scope, try one of these free for 10 days!

NMOS filter chip passes CMOS in power drain

An NMOS—not CMOS—PCM-codec filter chip from Mostek Corp. (Carrollton, TX) will consume ten times less power than other standard NMOS filter chips. What's more, its 20-mW dissipation means that it consumes about one-third less power than CMOS—the traditional low-power process—chips.

What's more, there's another NMOS breakthrough—this one involving noise sources. According to Mostek, idle-channel noise—that potentially annoying buzz when no one is talking—is 3 to 6 dB lower than on the standard 2912 PCM filter chip.

Cost, too, is being cut—the 77 × 108 mil^2 of silicon covered is just one-third that of other NMOS devices and half that of proposed CMOS devices. In addition, advanced-converter circuitry in the chip uses all-capacitive ratioed filtering for the critical-response elements instead of an R-C filter, which requires cost-producing trimming.

The small chip size, trimless filtering and the matured NMOS technology should give excellent yields.

One-chip controller handles 8 sync protocols

With a big boost from IC chips, switching from one port to another to change the synchronous data-comm line protocols in high-speed terminals, controllers and computers is destined to become as passe as RTL. One new chip, the F6856 Synchronous Protocol Communications Controller from Fairchild's MOS Products Group (San Jose, CA), obsoletes port switching by allowing a programmable choice of eight synchronous-protocol versions on an I/O port. In addition, unlike other IC protocol controllers, this one handles almost all popular synchronous protocols.

What's more, the F6856 does not lean on a CPU's intelligence once data transfer starts. All the processor need do is enter the required programming data (into the unit's four addressable registers) that specify one of eight synchronous protocols and options within that protocol. The chip takes it from there.

After receiving the initial programming preceding a protocol change, the chip performs all the following functions:

- Converting the received bit-serial line data to either 8 or 16-bit parallel words for a bus, while concurrently performing the inverse parallel-to-serial conversion for transmission. In this way, the TTL-compatible chip permits full-duplex operation with an 8 or 16-bit directional data bus at rates ranging from dc to 1 Mbit/s.
- Converting line-transmission codes to computer codes—for example, NRZI to NRZ—while monitoring the transmitted bit stream and characters for such control designators and delimiters as SYN, FLAG and ABORT.
- Inserting and deleting the bits or characters required by the protocol in use.
- Interrupting the processor either after a message has been completed normally or for such abnormal conditions as overruns or underruns.
- Generating cyclic-redundancy checking (CRC) characters and performing popular options of the CRC checking. The CRC function is done on-chip without additional circuitry.
- Performing the basic self-testing function by internally connecting its transmitter output to its receiver.

The chip handles not only the popular byte-control protocols (BCPs) like Bisync and DDCMP but also the newer bit-oriented protocols (BOPs) like SDLC, HDLC and ADCCP. Two versions of Bisync can be programmed, one using USASCII code and the other using EBCDIC code.

BIMOS op amps excel in BIFET territory

Analog designers will soon be able to choose between BIMOS and BIFET mixed technologies for "equivalent" monolithic operational amplifiers. Early next month, RCA Solid State Div. (Somerville, NJ) will market its BIMOS versions of the BIFET TL080 series originally introduced by Texas Instruments (Dallas, TX). RCA's CA080 series of op amps will offer a MOSFET input on the same chip with a composite bipolar/MOS output, instead of the junction-FET input and bipolar output of the BIFET devices.

The difference in technology buys the circuit designer somewhat faster slewing and broader bandwidths—but most importantly, appreciably lower input bias current (40 pA for BIMOS versus 400 pA for BIFET) and higher input impedance. The BIMOS op amps also provide a wide common-mode input voltage range and a wide output-voltage swing.

The RCA op amps will come in single and dual versions, compensated and uncompensated, and in both plastic dual-in-line packages and TO-5 metal cans.

GPIB controllers handle programmable supplies

A combination of digitally programmable power supplies and IEEE-488 compatible controllers can add up to easy set-ups for automated test systems. Kikusui International Corp. (Carson, CA) has developed a series of five supplies to work with any of three types of controllers.

Each controller can handle as many as 15 supplies, which can deliver either bipolar or unipolar outputs with programmable voltages and currents.

Typical output accuracies are 0.05% and full-range response times are 300 to 500 μs, with voltages from 4 to 100 V and currents as high as 5 A. Supply requirements are 120 V and 100 VA.

Control signals for the supplies are polarity, strobe, data clear, range, direct zero, address, standby, set, direct standby and output current or voltage. Alarm outputs to the controller are address correct, DAC, error flag (over data, range not correct), thermal down, ready and voltage or current limit.

Automatic voltage to current crossover is available. Controllers are available as CPU interface, non-CPU control or manual. The non-CPU unit is capable of 64 programming steps resident in nonvolatile memory.

Counter/timer sets trigger levels by itself

Using an 8-bit microprocessor, an enhanced version of the Racal/Dana (Irvine, CA) 9000A counter/timer sets counter-trigger levels automatically, with no operator assistance. One major benefit of this approach is the elimination of trigger errors or false counting due to input signal noise during frequency and period measurements.

To implement the function, the 8-bit CPU sets the voltage range to 100 V, then scans the peak-to-peak excursions of the incoming signal to see if any peak exceeds 30 V. If they don't, the CPU down-ranges to the 10-V range and scans the incoming ac for a level greater than 1 V. If it finds none of these peak-to-peak amplitudes over a volt, the CPU further down-ranges to the 1-V range.

Once the incoming signal has been sorted into one of these three ranges, the counter CPU measures the maximum and minimum peak of the input signal, calculates the arithmetic mean of the two, then sets the trigger level to this mean.

μP-based analyzer takes on automotive tasks

Automotive electronics will take several steps forward with the introduction of the 454-μP-based engine-analysis system from Siemens (Cherry Hill, NJ).

Using the 6800-family μP, the system compares data on automobile types from Siemens FDD-100-5 and FDD-200-5 floppy-disk drives, with the inputs coming from a host of transducers, including a Hall-effect current probe, a pressure/vacuum sensor, temperature probes and an infrared emissions analyzer. Then the $25,000 system displays the results in alphanumerics on a CRT.

Briefs

A new CW laser will use a thermoelectric cooler to stabilize light output, lower drive current, and lengthen its life. Developed by Laser Diode Laboratories (New Brunswick, NJ), the LDT-264 features an LDL SCW 20 or LCW 10 laser, temperature-monitoring circuitry, and a thermoelectric cooler inside a hermetically sealed 14-pin DIP package. The cooler will keep laser temperature to within small variations of 20 C. Drive current is typically 85 mA at 2 V, and light output is typically 2 mW into a 125-μm fiber pigtail with a 55-μm core.

High-brightness LEDs that can take the place of incandescents will soon be announced by General Instruments Opto-Electronics Div. (Palo Alto, CA). Using a gallium-arsenide phosphide epitaxial structure on a gallium-phosphide substrate, the diodes will provide ten times the light output of a normal LED—that means 80 mcd, typically, with a viewing angle better than 140° and less than 500-mW input. Operating half-life is better than 100,000 hours.

Rapid etching of gold interconnections on hybrid circuits and semiconductor lead frames at low temperatures will be provided by a cyanide-based gold-etchant formula to be announced by Union Etchants International (Woburn, MA). Currently being tested by National Semiconductor (Santa Clara, CA), the gold etchant will lift 2000 to 3000 A in 60 seconds at 10 C. Though the process can be quickened by increasing the etchant temperatures, etching at low temperatures will minimize the cyanide fumes and thus help make gold etching compatible with OSHA regulations. In addition, the gold will not crystallize in the etching solution, which will encourage efforts to recover the gold.

A multiboard data-acquisition system combines front-end analog-signal conditioning with an a/d converter to accept any type of analog input—even in the presence of ground loops. Compatible with Motorola's EXORcisor, the Series 6800 Industrial Data Acquisition Subsystem from Acromag, Inc. (Wixom, MI) is built around the company's 6810 a/d base card and one or more optional expander cards.

Two low-cost streaming tape drives that provide backup for Winchester disks are available from Data Electronics, Inc. (San Diego, CA). The two-track, 10-Mbyte and four-track, 20-Mbyte drives transfer data at 5 Mbytes/min. and, with optional circuitry, yield data reliability of 1 in 10^{10} hard read errors. Available in small quantities, they sell for $746 (10-Mbyte) and $788 (20-Mbyte).

A multifunctional, multiprotocol terminal combines the features of an intelligent terminal with the benefits of a desktop data-processing system. The Series 4500 terminal from ECS Microsystems (San Jose, CA) handles high-level development languages, supports 75-baud to 19.2-kbaud synchronous or asynchronous communications.

The longest fiber-optic telecommunications link will connect 19 switching stations between Cambridge, MA, and Washington DC, when it is put into service in January, 1983. Manufactured by Western Electric (Atlanta, GA), the 611-mile FT3 System will transmit up to 44.7 Mbits/s (equivalent to 80,000 simultaneous phone calls) at 820 nm. The $79-million system incorporates million-hour lasers and avalanche photodetectors developed at Bell Laboratories (Murray Hill, NJ).

Transformers that show no thermal aging after 400 hours at 500 C have been developed by General Magnetics (Bloomfield, NJ) in conjunction with high-temperature research at Sandia Labs (Albuquerque, NM). The transformer cores are 50% nickel and 49% cobalt; windings are made of 44-gauge anodized aluminum. While intended for oil-well drilling, jet engine controls and other high-temperature applications at 400 Hz and 10 kHz, the devices should prove useful from 100 to 40 kHz.

Say goodbye to your old Analog RMS Voltmeter.

And say hello to Fluke's family of True RMS Digital Voltmeters at analog prices. The advantages of a digital voltmeter's speed and accuracy have finally come to wideband true rms measurements. Thanks to an exclusive Fluke-designed microelectronic chip, you can now make true rms measurements with an ease never before possible—and starting at just $1095*.

Try this on your old analog meter. Each model boasts an autoranging LED display of volts (3½ digits) or dB (4½ digits) with 0.5% midband accuracy. An exclusive "dial-a-reference" feature lets you match the instrument's dBm reference to the impedance of the system you're working with. The resultant direct reading of dBm eliminates time consuming calculations. With the relative dB feature, you can set the existing dB reading to zero establishing the input voltage level as the dB reference. Subsequent readings will be indicated as ± dB. All with ac or ac + dc input coupling.

For simplified peaking/dipping measurements, an analog meter complements the digital display. Counter and log output options are available for your system applications.

Match the model to your measurement needs. There's no compromise when buying a Fluke True RMS Voltmeter. The 8920A and 8921A boast 10 Hz to 20 MHz specifications with a 2 mV range to 2 MHz. Choose the 8920A with a BNC input or, for floating measurements to 500V, the 8921A with isolated banana jacks.

The 8922A, newest in the series, includes design enhancements for both audio measurements (with specifications to 2 Hz) and rf applications (with an 11 MHz, 2 mV range). Selectable 200 kHz filtering enhances audio performance by eliminating unwanted high frequency noise.

IEEE-488

Latch them together, then put them on the bus. Each 8920-Series Voltmeter is housed in the exclusive Fluke portable test instrument package. This system allows convenient stacking and latching of multiple instruments for unrivaled transportability. And by adding the new 1120A Translator, with appropriate instrument options. you can make your new voltmeter IEEE-488 compatible.

See how the 8920 Series measures up. For immediate response, contact the Fluke sales office or representative in your area or call:

800-426-0361

If you prefer, just complete and mail the coupon below.

FLUKE®

IN THE U.S. AND NON-EUROPEAN COUNTRIES:	IN EUROPE:
John Fluke Mfg. Co., Inc. P.O. Box 43210 MS #2B Mountlake Terrace, WA 98043 (206) 774-2481 Telex: 32-0013	Fluke (Holland) B.V. P.O. Box 5053, 5004 EB Tilburg, The Netherlands (013) 673-973 Telex: 52237

☐ I'd like a demonstration.
☐ Please send me information on 8920-Series True RMS Voltmeters.
☐ Please send 1120A IEEE-488 Translator information.

Name
Title Mail Stop
Company
Address
City State Zip
Telephone ( ) Ext.

ED2 2/80

*U.S. Prices Only

CIRCLE NUMBER 15

...WHEN A 10V, 10mA OP AMP WON'T DO THE JOB!

When you need output voltages to ±145VDC or output currents to ±5 amps - for power demanding jobs that small signal op amps can't handle - these complete high voltage / high current amplifiers offer an easy solution.

We've put good amplifier performance in compact IC packages that solve both electronic and mechanical design problems. You don't have to create extra output stages anymore. Fully isolated, the 8-pin TO-3 cases of these amplifiers can't short out - are simple to heat sink.

Now it's really simple to increase your output! Details from our sales office nearest you!

MODEL	OUTPUT			POWER TO LOAD - WATTS	
	VOLTAGE	CURRENT			
		Cont.	Peak	Cont.	Peak
3583	±40 to ±140V	±75mA	±100mA	10.5	14
3582	±65 to ±145V	±15mA	±25mA	2.2	3.6
3581	±27 to ±70V	±30mA	±50mA	2.1	3.5
3580	±10 to ±30V	±60mA	±100mA	1.8	3.0
3573	±20V	±2A	±5A	40	100
3572	±30V	±2A	±5A	60	150
3571	±30V	±1A	±2A	30	60

BURR-BROWN
BB

Putting Technology
To Work For You

CIRCLE NUMBER 151

AUSTRIA - Wien 0222/62 63 71 - **FRANCE** — Le Chesnay, 954-3558 - **GERMANY** - Hauptsitz, Filderstadt 1, 0711/70 10 25; Bremen, 0421/25 39 31; Neuss, 02101/30738; München, 089/61 7737; Berlin, 030/8831058 - **HOLLAND** — Schiphol, (020) 470590 - **JAPAN** - Tokyo (03) 586-8141 - **SWITZERLAND** - Rüschlikon, 01/724 0928 - **UNITED KINGDOM** - Watford, (0923) 33837 - (Other areas contact) **BURR-BROWN,** P.O. Box 11400, TUCSON, ARIZONA 85734 USA - Tel: (602) 746-1111 - TWX: 910-952-1111 - Telex: 66-6491 - Cable: BBRCORP

Memory, LSI failures—and solutions—abound at international symposium

Improving bubble-memory failure rates, while a major highlight, is just one of several key topics to be scrutinized at the International Reliability Physics Symposium. Other discussions will focus on semiconductor-surface contaminants, overstress on LSI devices, inspection of PROM links, data retention in EPROMs, and alpha-particle-induced errors in LSI and VLSI.

Several failure mechanisms have been uncovered and observed in accelerated tests on bubble memories at Bell Laboratories (Murray Hill, NJ). In temperature cycling tests (−40 to 100 C), permanent-magnet demagnetization and wire-bond breakage does occur. The barium-ferrite permanent magnet material can demagnetize and thus reduce the bias field in bubble devices at −40 C. While this effect appears to be negligible, lower temperatures will require more involved ways to set up magnets. Also, several failure modes were observed in the wire bonds, the most serious being separation of the bond from the gold-plated conductor on the circuit board.

In temperature-humidity tests performed at 85 C/85% RH with 20-V bias, circuit board corrosion was observed as the most frequent failure mode. In this case, however, the meantime to failure (MTTF) can be extended from approximately 200 to 2000 hours by careful selection of chip cement and casting resin. What's more vibration tests involving frequencies from 5 to 250 Hz at amplitudes of 10 g and shock tests to 100 g caused no problems in the bubble-memory devices. And electromigration tests on the Al-4%Cu conductor associated with the bubble generator (which requires the highest current density), when performed on 40 generators at 50 MHz and 100 C, has yielded no failures in eight months of continuous testing.

A bubble-memory study by Rockwell International (Newport Beach, CA), focusing on production testing of bubble memories, has found that because of large chip capacity and the attendant complexity of testing, defective loops may go undetected. Problems in the field could result should data be written into defective loops—data contamination in adjacent good loops, for one, and even destruction of all the stored data.

Ron Shinn
Field Bureau Editor

Defects spill over

Defective storage loops vary in magnitude. A writable defect will only affect those bubbles in the defective loop, but not in the adjacent loops. A nonwritable defect will also contaminate the data in the adjacent loops, and, in extreme cases, may destroy all the stored data.

The Rockwell study reveals several ways to uncover the nature of the defects: whether there is excess or missing permalloy film in the device, the size and location of the defect, and such operating conditions as bias field, rotating field and operating temperature.

On an even more positive note, an application study of bubbles for electronic switching systems (ESSs) conducted by Nippon Telegraph and Telephone Public Corp. and Hitachi Ltd. (Japan) demonstrates that 4-Mbit units fabricated for this use have enough reliability to last 22 years.

The unit is a module, holding 64-kbit chips. The chips used in the unit are composed of conductor loops made of evaporated 0.52-μm-thick Al-Cu film with 4.2-μm minimum line width, and bubble propagation channels made of 0.36-μm-thick permalloy film with 2.7-μm minimum line width. The chip surface is coated with SiO_2 film for passivation.

Want to go?

The 1980 International Reliability Physics Symposium will be held at Caesars Palace (Las Vegas, NV, April 8 through 10). For an advance copy of the program and registration information, contact W.L. Harrod, Room 3B-301, Whippany Road, Whippany, NJ 07981; (201) 386-3830.

Meanwhile, IBM (Hopewell Junction, NY), experimenting on conducting stripes, has found good correlation between time to failure in pulsed high-current-density electromigration experiments and the deviation from ohmic behavior. The results are in terms of a model where ohmic nonlinearity is the result of joule heating in the conducting stripe.

The observed correlation indicates that electromigration damage is a thermally activated diffusion phenomenon, and that hotter stripes will fail before cooler ones.

The prominent causes of failure in conductors carrying high current densities include electromigration and melting due to joule heating, according to National Semiconductor (Santa Clara, CA). An associated large temperature rise due to localized joule heating can also cause either metallurgical reactions in a multimetal metalization or chemical reactions with the passivation layer or atmosphere.

Standards limit choices

The major constraint in selecting a conductor system, according to National, is dictated by the industrial standards of 5 and 12-V power supplies. This constraint limits potential metalizations to systems with conductivities better than the Al-4% Cu alloy, which means conductor choices are limited to Cu, Ag, Au and Al-based systems.

Bubbles aren't the only subjects for discussion in Las Vegas. Hewlett-Packard (Corvallis, OR) has been observing the influences of temperature on the electrostatic discharge (ESD) susceptibility of MOS LSI devices using junction diodes as input protection. NMOS, PMOS and CMOS types from various manufacturers were found to be more susceptible to ESD voltages at 125 C than at 25 C. All MOS types tested use some form of junction diode as part of the input protection structure and the failure always occurs at the junction diode. Apparently, the doping level of the diode is a critical factor in determining the influence of ambient temperature. In addition, ESD voltage necessary to induce failure at 125 C is approximately 25% lower than that required at 25 C.

Also, a new failure mode has been discovered in the NiCr memory link in PROMs by the Charles Stark Draper Laboratory Inc. (Cambridge, MA). It's caused by a process-related fault concerning self-programming of an unprogrammed nichrome link during operation of a PROM under normal read conditions.

Links prone to this type of failure can be found with an electrical screen that augments visual inspection. A general test scheme has been devised to facilitate automation of the electrical screen on a high-speed tester using a brute-force algorithm. Moreover, a simpler algorithm can be used to appreciably reduce test time with no loss in capability for 100% testing, says Draper.

EPROM data retention is also subject to error—charge loss from the floating gate, which may result from either thermal excitation or radiation, according to Intel Corp. (Santa Clara, CA). In fact, EPROMs could be erased when electrons in the floating gate are photoexcited to pass into the conduction band of surrounding SiO_2 and drift to either the substrate or the word line gate.

In P-channel devices, the floating gate is P-type so these carriers must be excited from the valence band. This requires a minimum photon energy of 4.3 eV. For N-channel parts with N-type floating gates, only 3.2 eV is required to give electrons in the Si conduction band enough energy to escape from the floating gate. However, the density of occupied states in the conduction band is low compared to the density of states in the valence band —the resultant conduction-band photocurrent is small with respect to that coming from the valence band.

Bell Labs in Allentown, PA, has observed a new threshold-instability phenomenon in Si-gate MOS transistors encapsulated with plasma-deposited SiN films. Evidently, saturation-mode thresholds drift as much as −0.5 V when operating with high drain voltages.

The study concludes that the instability is a chemical effect associated with the hydrogen in SiN films. The basic instability mechanism appears to be the formation of surface states across the channel region in the presence of hydrogen and high-impact ionization.

Meanwhile, an examination of process defects and effects on MOSFET-gate reliability by IBM General Technology Div. (Essex Junction, VT) reveals that both visual-defect and electrical-failure concentrations are nonrandom in a selected oxide-nitride dielectric. Devices—examined before, during and after growth—include large capacitors (3709 μm^2), "long finger" interdigitated devices (290 μm^2), and two sets of gate chains with individual gate areas of 55.6 and 16.5 μm^2, respectively.

The gate film consists of a 45-nm dual dielectric, with Al-Cu as the electrode. No clear indications of defect density dependency on discrete process levels were noted.

Of the several thousand chips studied, a portion of those with previously observed defects were tested and subjected to a life stress of 3.8 mV/cm, 150 C. Two out of 141 of the observed defects failed within 24 hours, while two others failed at test. The conclusion? Smaller gates will have much higher defect levels.

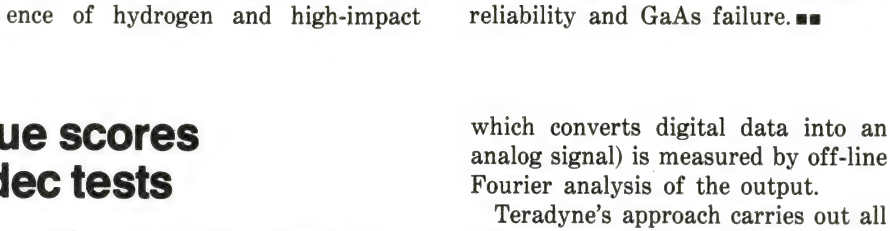
Several studies on alpha-particle-induced failures will also be presented at the symposium, along with studies of encapsulants, contaminants, solar-cell reliability and GaAs failure. ■■

Analog-digital technique scores with fast, accurate codec tests

By testing codecs with both digital and analog signals, Teradyne speeds up measurements and increases their accuracy—gain tracking, for example, takes 6 ms with an accuracy of ±0.02 dB. The accuracy of Teradyne's (Boston, MA) A300 Analog LSI test system is especially impressive considering that typical codec specifications call for ±0.2-dB accuracy and that the industry's D-3 specification for channel-bank compatibility demands an accuracy of ±0.5 dB.

The major alternate approach to codec testing, as represented by Fairchild Systems, San Jose, CA, (ELECTRONIC DESIGN, Feb. 1, 1980, p. 59), relies upon digital implementation only. First, an audio stimulus is generated by sending digital data of known quantity to a digital-to-analog converter. The resulting analog signal is applied to the codec's encoder, which converts analog data to digital. To measure the encoder output, Fairchild compares the digital data emitted by the codec against known-good data. The decoder (that part of the codec which converts digital data into an analog signal) is measured by off-line Fourier analysis of the output.

Teradyne's approach carries out all measurements in real time. First, Teradyne employs a precise analog signal source to stimulate the codec's encoder. The encoder's digital output is converted back into analog by a specially designed reference decoder. The converted data are measured in real time by a precise digital voltmeter (DVM),



Teradyne's system tests a codec's encoder with a precise analog signal and tests the decoder with a PCM digital signal.

Jonah McLeod
Instruments Editor

which also measures the analog output of the decoder. With Teradyne's technique, off-line calculations are not needed to determine instantaneous ac voltage; the information is merely read from the system's DVM.

According to Jim Hayes, product manager of telecommunications, reference decoders are generally used for testing linear devices; but Teradyne's device has five times the accuracy required of any codec function being tested. It also has 21 bits of linearity. "It won't add distortion or inaccuracy into the digital information."

Teradyne's procedure starts when an analog sine wave of a programmable amplitude and frequency is applied to the input of the decoder. Usually, this input is a 1020-Hz signal.

Within the encoder, 400 samples on the sine wave are encoded into 8-bit digital bytes. The sampling rate ensures that the first sample on the 1020-Hz signal does not correspond to any other of the 400 samples taken on the waveform. In effect, the sample moves along the wave. The frequency itself is in the middle of the response scale of the filter and the gain curve of the codec.

The 8-bit digital bytes are supplied to the communications channel at the encoder output, where the reference decoder of the tester is placed.

The reference decoder converts the encoder's digital output into an analog signal. This waveform is then presented to the audio voltmeter via the filters used in the decoder test. In this respect, the encoder and the decoder are tested identically: The voltmeter measures an analog stimulus supplied to each.

For decoder testing, a digital bit stream, corresponding to an analog signal of known amplitude and frequency, is supplied to the decoder from RAM memory in the tester. This digital bit stream kits then decoded in the codec and supplied as an analog signal to the filter and to the audio voltmeter. The DVM compares the analog signal in real time against the expected waveform.■■

One-two gold-inlay process speeds connector-contact production

While manufacturers of connector and switch contacts and semiconductor lead frames seek ways to conserve gold in the contacts, Technical Materials Inc. (Lincoln, RI) has developed a cost-cutting way to implant precious-metal inlays on the copper strips from which the contacts will be stamped: Groove the base metal and insert the inlay in one pass, using the same machinery. This skiving process provides considerably higher throughput than milling or electron-beam welding processes, produces smooth surfaces, and allows close tolerances in the precious metal insert.

In the process, grooves or channels are scraped into the surface of a strip of contact metal, such as copper alloy. But even as the grooves are being formed, strips of precious metal inlay are rolled into the groove. The connector or switch contacts are then stamped from the inlaid strips.

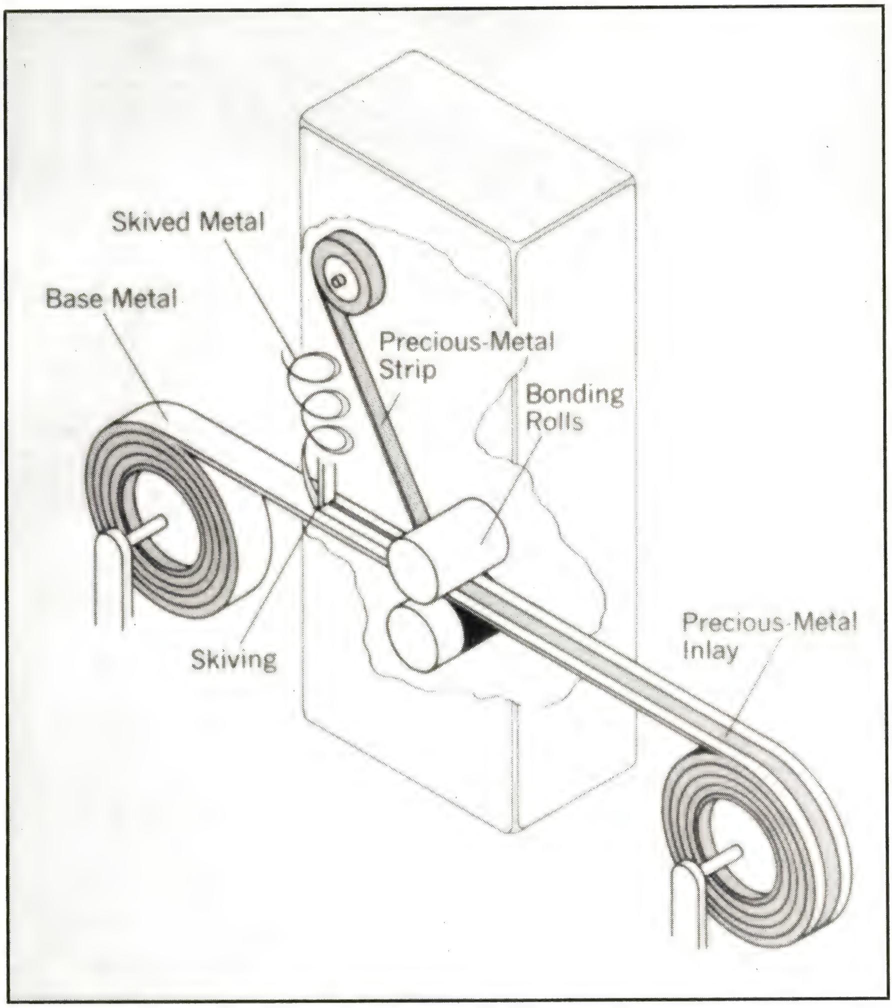
Milled metal strips would still require electron-beam welding or some other process to implant the precious metal inlays. As a result, the throughput increase with skiving jumps well above that of milling—175 ft per minute to 10 ft/min.

Rolling in the precious-metal inlay, moreover, reduces the thickness of the metal strip by almost half. This not only smoothes out the surface, it also strengthens the bonding between the base metal and the inlay. The result is uniform stresses in the stamped contact without the need for additional coining or stress relief.

The resulting contacts are especially useful in applications where the inlay must provide spring-loaded contact on a switch or PC-board contact pad.

As for the specific challenge to economize on gold use, TMI is working on additional saving alternatives.

First, gold inlays can be recovered from the stamped scrap metal by using



In the skiving process developed by TMI, the base metal is grooved and the precious-metal inlays are inserted in the same operation.

Stephan Ohr
Components Editor

specially designed stamping dies that automatically segregate inlay material from other scrap in the stamping process. Indeed, TMI vice president Craig Harlan states that 90% of the precious-metal inlays could be recovered.

Second, TMI advocates palladium-silver formulations as a possible alternative to gold. A 60 Pd, 40 Ag combination reduces not only the polymer formation that has plagued pure palladium, the company maintains, but also the tarnish that has made pure silver unsuccessful. Assuming $600/oz for gold, $180/oz for palladium and $40/oz for silver, the palladium-silver inlays will cost less than 13% of an equivalent gold inlay. ■■

Power-supplies take on high-frequency designs, aided by improved modeling

Even as power-converter designs concentrate increasingly on high frequencies, new complex modeling and analysis techniques are helping simplify the job. As a result, major design issues—MOS vs bipolar transistors, high-frequency topologies, magnetic component design and selection—will share center stage with sophisticated ways to predict switcher performance at Powercon 7.

One new development is a one-of-a-kind square wave design that can handle an extremely high frequency for a switcher—400 kHz. The key is at the output. Where step-down buck converters usually provide only a single-polarity output, a supply designed by Willard Strong Aeronutronic Div. of Ford Aerospace (Newport Beach, CA) offers positive as well as negative outputs, controlled by a feedback signal from the load together with a manual input. Four VMOS transistors form two complementary transistor pairs in the output drive circuit. In each pair, the n and p-type devices are pulse-width-modulated, which sets the output amplitude.

At the same time, high-frequency sine-wave converters could exhibit several advantages over present high-frequency square-wave techniques used in present switching regulators, says Dilip Amin of Hewlett-Packard's New Jersey Div. (Rockaway, NJ). Square-wave devices, Amin will point out, suffer from a major problem—voltages and currents contain multiharmonic frequencies difficult to filter. But sine-wave converters have fewer filtering problems of internal noise and EMI (radiated and conducted).

Theoretically, then, sine-wave converters can operate at frequencies as high as square-wave converters. Practically, however, components (transistors, magnetics, etc.) impose the same problems on both sine-wave and square-wave power supplies operating at high frequencies.

Higher-frequency problems

One problem growing more apparent at high frequencies is that circuit components and topologies that work effectively at 20 kHz simply do not work at 100 kHz and up, according to Rudy Severns of Intersil, Inc. (Cupertino, CA). (He will lead two seminars on explaining the crucial differences.)

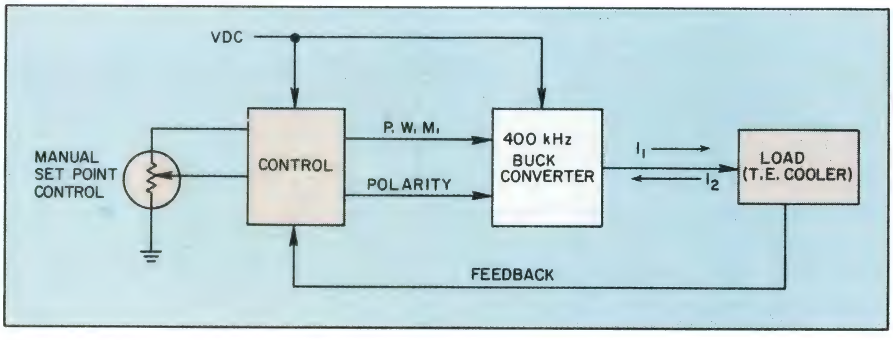
For example, bipolar transistors, a staple in low-frequency switchers, have an excessive storage time that prevents them from operating at high frequency unless special base-drive techniques are used. While anti-saturation and overdriving would help, another alternative is to go to a different transistor entirely—MOS. Consequently, not only the characteristics of MOS power transistors, but also ways to design them into high-frequency converters will be examined.

With MOSFETs looming larger in the high-frequency picture, Dennis Gyma, John Hyde and Dan Schwartz of Hewlett-Packard's New Jersey Div. will consider the implications of replacing bipolars with MOSFETs. From the gate-terminal side, they will discuss the significant parameters to consider and the various circuits to be used to provide gate drive. From the output side, the authors will examine the important factors involved when FETs switch repetitively in load driving situations. Other considerations not to be overlooked include the effect of the device's positive temperature coefficient, methods of determining junction temperature, and ways to predict how FETs share current.

Meanwhile, many of the stickiest problems at high-frequency concern magnetics (transformers and inductors) and capacitors. Different magnetic materials are, of course, required at high frequency, but, more important, there are very effective ways to wind transformers for operation above 100 kHz and achieve the required broadband coupling. And, while designers can take advantage of readily available plastic and film capacitors at high frequency, there are ways to lower a capacitor's impedance and increase its self-resonant frequency. The seminar will offer insights into the latest design techniques.

Focus on magnetics

Chief among design problems in high-frequency converters are those involving transformer and choke configurations and materials. But help may be on the way in the form of Metglas, a metallic glass that shows promise as a high-frequency core and transformer material (ELECTRONIC DESIGN, Feb. 1, p. 26). David Nathasingh and Carl Smith of Allied Chemical (Morristown, NJ) will compare Metglas against tape-wound toroids for core losses and permeability



Based on a standard buck regulator, this 400-kHz switcher designed at Ford Aerospace has a unique feature—its output is dual polarity, controlled by gating the output transistors.

Gene Heftman
Field Bureau Editor

ROLM's Mil-Spec ECLIPSE® Data System... a new power in military computers

Military operations on the move make tough demands on data processing systems.

The computers must be compact, rugged, and reliable. The data base and operating system must be transaction-oriented for fast real-time, interactive processing.

That's why ROLM developed the Mil-Spec ECLIPSE Data System. It's tough and has all the proven advantages of Data General's ECLIPSE® architecture and software. The key is a sophisticated multiprogramming Advanced Operating System (AOS), which controls real-time, multi-user, and batch operations... all while effectively managing up to 2 Megabytes of main memory.

And with ROLM's Model 3353/3354 Mil-Spec Storage Module System, AOS manages up to 540 Megabytes of on-line disk storage. Language support is impressive: FORTRAN 5, PL/1, DG/L™, COBOL, and the INFOS® file manager.

For shipboard systems, this flexible computing power is fully compatible with Naval Tactical Data Systems when joined with ROLM's new 3400 Series Interfaces. These compact MIL-STD-1397 modules come in SLOW, FAST, ANEW, and SERIAL types with 8, 16, and 32-bit configurations. They are interchangeable and feature software transparency. Designers can configure a system to match the data requirements of any ship... without restriction on future expansion.

ROLM's Mil-Spec ECLIPSE System lets you move out with power never before available in a military computer system. Designed to meet MIL-E-5400, MIL-E-4158, and MIL-E-16400 specifications, it gives you extensive software, full peripheral support, and ROLM reliability and service.

That's Why We're #1 in Mil-Spec Computer Systems

ROLM MIL-SPEC Computers

4900 Old Ironsides Drive, Santa Clara, CA
95050 (408) 988-2900. TWX 910-338-7350.

In Europe: Muehlstrasse 19, D-6450, Hanau,
Germany, 6181 15011, TWX 4-184-170.

ECLIPSE and INFOS are registered trademarks of Data General Corporation.

CIRCLE NUMBER 17

in the 10 to 100-kHz region.

Designing and applying magnetic components for switched-mode converters will be discussed in a seminar co-hosted by Steve Smith of Quatt-Wunkery (San Francisco, CA) and Charles Mullett of Charles Mullett Associates (Los Angeles, CA). Such topics as flyback and base-drive transformers, inductors, EMI control techniques, winding geometrics and mechanical considerations will be scrutinized by Smith. Mullett will explore a little-known, less-used aspect of improving supply performance—using mag amps as post-regulators in multiple-output supplies. Power-supply efficiency with mag amps is superior to that possible with other post-regulator circuits.

Not all the problems affecting transformers can be solved with magnetic techniques. Core saturation, for one, must be attacked with electronics, as Raoji Patel of Unitrode Corp. (Watertown, MA) will explain. Core saturation results because switching transistors have different storage times. Moreover, it is very difficult to match devices for storage time.

Patel's solution is an inexpensive circuit that uses an SG2525 PWM IC, a power transistor, two diodes and two resistors—to provide symmetrical current to the transformer regardless of differences in device-storage times. The technique can be used in most types of switching regulators, including push-pull and half-bridge.

Besides new components, new circuit topologies will be proposed. Starting with such primary topologies as switched-mode and resonant converters leads quite smoothly into designing entirely new topologies.

But as attention grows on what to put into new designs, one fact grows clear: Predicting design success or failure with breadboarding or trial-and-error is no longer desirable. Fortunately, it is also no longer necessary. The approach has been simplified with computer circuit analysis packages that allow sophisticated modeling of pulse-width modulators (PWMs).

One powerful but economical method uses Fortran statements and subroutines to create a large-signal model of a PWM inverter, the main component modeling problem in switching-regulator analysis. As described by Vincent Bello of Norden Systems (Norwalk, CT), dc, small-signal ac, large-signal transient and loop analyses (open and closed) can all be performed at a computer time-sharing terminal.

On the other hand, David Blough and Walter Bradley of Westinghouse Electric (Baltimore, MD) will propose an analysis technique based on Newton's method of approximating a curve with a series of stair-steps. Applying the technique to dc/dc converters, Blough and Bradley conclude that any electrical network can be analyzed in a piecewise-linear fashion, yielding a time-dependent description of any voltage or current in a circuit.■■

Want to go?

Powercon 7 will be held at the Town and Country Hotel (San Diego, CA, March 24-27). For complete information on the tutorial exhibit program, technical sessions and seminars, contact Ron Birdsall or Ed Grazda at Power Concepts, Inc., P.O. Box 5226, Ventura, CA 93003; (805) 985-6978 or (805) 486-5463.

Semis on display

One aspect of Powercon that cannot be overlooked is that at least 29 semiconductor companies are expected to show their wares—an outpouring of products underscoring the high-frequency battle between the emerging MOS devices and the entrenched bipolars.

For designers caught in the middle, Dave Hoffman of Siliconix (Santa Clara, CA) will host a seminar on power-MOSFET technologies. Topics will include linear and saturation characteristics, switching performance, dv/dt limitations, multiple device operation and physical structures.

The bipolar view will be presented by William Skanadore of General Semiconductor Industries (Tempe, AZ). He will unveil a new high-voltage, high-power switching transistor that reportedly rivals MOSFETs in speed. A demonstration of the device will show it switching 20 A into a 400-B clamp with switching times (current fall plus voltage rise) less than 100 ns. In addition, the device boasts the typically low bipolar saturation voltage.

ATCR fights variations in ac power to protect data in computer mainframe

The low source loading of automatic tap changing regulators (ATCR) is the mainframe computer's best defense against power brownouts. Unlike larger and heavier power conditioners, such as ferroresonant and saturable core reactors, the ATCR is designed as an integral part of a line voltage regulator. It provides conditioned power to the computer so that typical variations in the power supplied is reduced to ±5% in the long term and ±10% in the short term.

Ron Shinn
Field Bureau Editor

Because ATCRs are 96% power efficient, wasting only 4% of consumed power in cast-off heat, they also keep the computer room cooler, according to Ruxton Tucker of Topaz Electronics (San Diego, CA).

ATCR devices are presently available up to 100 kVA in three-phase, 208Y/120-V configuration, and cost less than 20¢ per VA. They have a wide input regulation range of ±20% about nominal, which reduces to within ±5%, or 6 V, about a 120-V ac line.

Power disturbances in the electrical energy supplied to computer mainframes by utility power lines can be as great as +5 to −17.5% in the long term, and +150 to −100% in the short term; but computer tolerance is only +10 to −8% long term and +15 to −18% short term.

Even with the added precaution of producing ac power from a separate source, computers are not really designed to withstand the total effects of the power changes that are sometimes delivered by the present transmission system.

Handline power-line noise

Long-term power deficiencies are accompanied by noise, which is hard to eliminate. Voltage spikes and ringing transients are transmitted down the

Announcing high performance Z-80A® in-circuit emulation for your Intellec® development system!

Now, from RELMS,® the incredibly powerful Z-80A SPICE,® in-circuit emulator.

If you are designing Z-80 microprocessor-based products, and own or use an Intellec Microcomputer Development System, then SPICE, from RELMS, is the most powerful development and debugging tool available.

This proven design aid lets you emulate in real-time Zilog's Z-80 and Z-80A microprocessors. SPICE is completely compatible and plugs directly into the Intellec 800, 888, and Series II models 220 and 230.

SPICE lets you develop Z-80 software utilizing its powerful relocatable macro assembler. Hardware can be developed at 4 MHz.

Z-80 SPICE boasts the new concept of in-circuit emulation called *breakregion,*™ allowing you to halt emulation and isolate a hardware fault or a software bug.

SPICE lets you select machine cycle or instruction trace. SPICE lets you collect virtually unlimited trace history on disk. With SPICE, you can test your product with disk-based command files automatically, and debug your prototype in real-time wherever you may be in the development cycle.

Z-80 SPICE is only available from RELMS — Relational Memory Systems.

Upgrade your Intellec 800 or 888 to Z80A capability with SAM — RELMS' powerful System Adaptor Module.

Z-80ASAM retains compatibility with all Intellec 800 hardware and software features for 8080A and 8085. PL/M, FORTRAN-IV, BASIC and 8048 cross assemblers run at 4 MHz.

If you are an Intellec 800 or 888 user, let RELMS' Z-80ASAM (System Adaptor Module) boost your power to the Z-80 or Z-80-A level. Replace the 8080 processor card in your Intellec system with SAM and you'll have all the architectural features of the Z-80 CPU ready to get you developing Z-80 software fast, at 4 MHz.

RELMs' Z-80 SAM System Adaptor Module comes complete with Z-80 Relocatable Macro Assembler, Macro Monitor and Executive Monitor.

Expand your Intellec capacity with macro assemblers.

RELMS' five relocatable macro-assemblers can help you increase the universality of your Intellec system. They are compatible with Fairchild, Motorola and Mostek Zilog language definition features, and produce an ISIS-II-compatible output.

F8/3870/3872 RMA	$500
6500/6501/6502 RMA	$500
6800/6801/6802 RMA	$500
Z80 RMA	$500
6809 RMA	$500

Relational Memory Systems, Inc.
1180 Miraloma Way
Sunnyvale, CA 94086
(408) 732-5520
TWX 910 379 0014

relms

CIRCLE NUMBER 18

SAM and SPICE sound really nice, RELMS!

☐ I want more ☐ SPICE information ☐ SAM information ☐ Assembler information immediately! Call me at (______)______-__________.

☐ Please send me your SPICE brochure and data sheet. ☐ Please send me your SAM brochure and data sheet. ☐ Please send me your Relocatable Macro-Assembler data sheet.

☐ I'm interested in all of RELMS' high performance development tools for my application, which is:

____

Name______________Title______________
Organization______________________
Street______________________
City__________State__________Zip__________
Phone (______)______-__________.

ED 2/15/80

Z-80A® is a registered trademark of Zilog, Inc.
RELMS,® SPICE,® SAM® and Breakregion™ are registered trademarks of Relational Memory Systems, Inc.

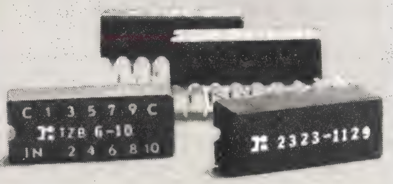
Intellec® is a registered trademark of Intel Corporation.

WHY
RHOMBUS
CAN
OFFER
YOU
MORE
IN A
DELAY
LINE.

All our lumped constant delay lines exhibit the highest obtainable delay to rise time ratio, are extremely temperature stable and feature low attenuation. Rhombus delay lines are inductive tapped and have low DC losses; and we offer 8 to 28 pin packages and profiles to .125 high. Passive and buffered delay lines meet or exceed all applicable MIL SPECS.

For products catalog and complete information, call (714)898-0960 • (213)594-8918 or write Rhombus Industries Inc., 15801 Chemical Lane, Huntington Beach, CA 92649.

RHOMBUS, for all your timing/clocking needs.



RHOMBUS
INDUSTRIES
INC.

CIRCLE NUMBER 19

utility power lines, right along with the power. Disturbances are created by lightning: by consumers on the line who make heavy load changes; and by the utility, when it places fault correction devices in the network, corrects power factors and switches networks.

Often, isolation from transmission-line noise is gained with a frequency converter, which is a mechanical or electronic device that receives ac power at 60 Hz and converts it to 415 Hz. Processors like the 3033, 3032, 370/165, 370/168 and 470V5-6-7 use a separate 415-Hz power source, for instance.

Both approaches protect the central processing unit from common-mode and transverse-mode noise on the power line. However, they fail to protect other equipment operating in the computer room, which needs protection from noise almost to the same extent as the central processing unit.

For that reason, manufacturers specify power line requirements, even when using a separate 415-Hz generator.

For example, IBM's installation-management manual states the equipment "will tolerate variations in the normal rated voltage of +10 to −8% for extended periods of time." IBM defines "extended periods of time" as being longer than one-half second, or 30 cycles of a 60-Hz power line.

The industry's rulemaker, ANSI, allows the minimum voltage to be 7.5% below nominal, as delivered to the service entrance by the utility. Therefore, equipment is designed to operate at just 0.5% (0.6 V on a 120-V line) above specified voltage under static conditions.

The utility is legally required to provide a minimum of 111 V ac at the service entrance. Mainframe computers will operate satisfactorily with a minimum input voltage of 110.4 V ac, only 0.6 V from the minimum requirement.

In 1974, IBM engineers George Allen and Donald Segall reported an average of 14.4 low voltages to a computer site per month. They counted the average number of excursions of voltage that were more than 10% below nominal. In other words, they counted only those excursions below 108 V ac on a 120-V line.

According to a 1974 publication of the U.S. Department of Commerce, out-of-tolerance voltages occur thousands of times per year. Allen and Segall reported an average of 128 excursions per month.

As a way of reducing energy output to meet peak demand periods, the utilities have developed the brownout. The brownout is a planned voltage reduction in which reduction steps of 3%, 5%, 7% and 10% are allowed. To date, 7% has been the largest reduction typically experienced by utilities.

When all the allowable long-term or static conditions affecting the voltage are added together, it is easy to see that the power to a computer could be out of tolerance often. Consider the following:

- ANSI-allowed voltage at service entrance: −7.5%
- Building code allowable drop across service entrance: −1%
- Building code allowable drop across main fuse panel: −1%
- Building code allowable drop across subcircuit: −1%
- Typical brownout: −7%
- Total deviation from nominal: −17.5%.

Transients add to the problem

All of the power line disturbances listed are static conditions. Power line disturbances also occur as short-term (transient) voltage changes caused by load starts, network faults, and utility regulating devices and procedures. These short-term voltage changes merely compound the total problem. As the use of electrical energy increases over the next few years, these short-term voltage problems will also increase.

The transient or short-term disturbances can be filtered; but filters add impedance to the power line and that merely worsens the long-term effect, as heavy and frequently changing loads cause voltage drops across the impedance.

ATCR prevents damage

With an ATCR, computer input power requirements are readily met. The power line conditioner can actually be used to prevent error and damage. With conditioned power, programs need not be rerun and downtime is not incurred for service calls.

Ferroresonant transformers, saturable core reactors or ATCRs, if properly filtered, will provide adequate long term and very good short-term protection.

But response time, output impedance and the effect of power factor loading should be taken into consideration when choosing between the types of power line conditioners available.

The devices compare as follows:

- Ferroresonant regulators respond in 2-1/2 cycles with an output impedance that is 15 to 30% of load.
- Saturable core reactors respond in 5 to 10 cycles with an output impedance that is 30% of load.
- Automatic-tap-changers respond in only 1 cycle, with an output impedance that is 2 to 4% load. Unlike the other regulators, the ATCR does not affect the power factor.

Computer load peaks

It should be noted that a computer load is far from static. It has many high peaks of inrushing current during turn-on and normal operation. The typical mainframe computer also has a 0.8 lagging power factor caused by the inductance of fan motors, disc drive motors, magnetic tape drive motors and even the chokes used in the dc power supply filters.

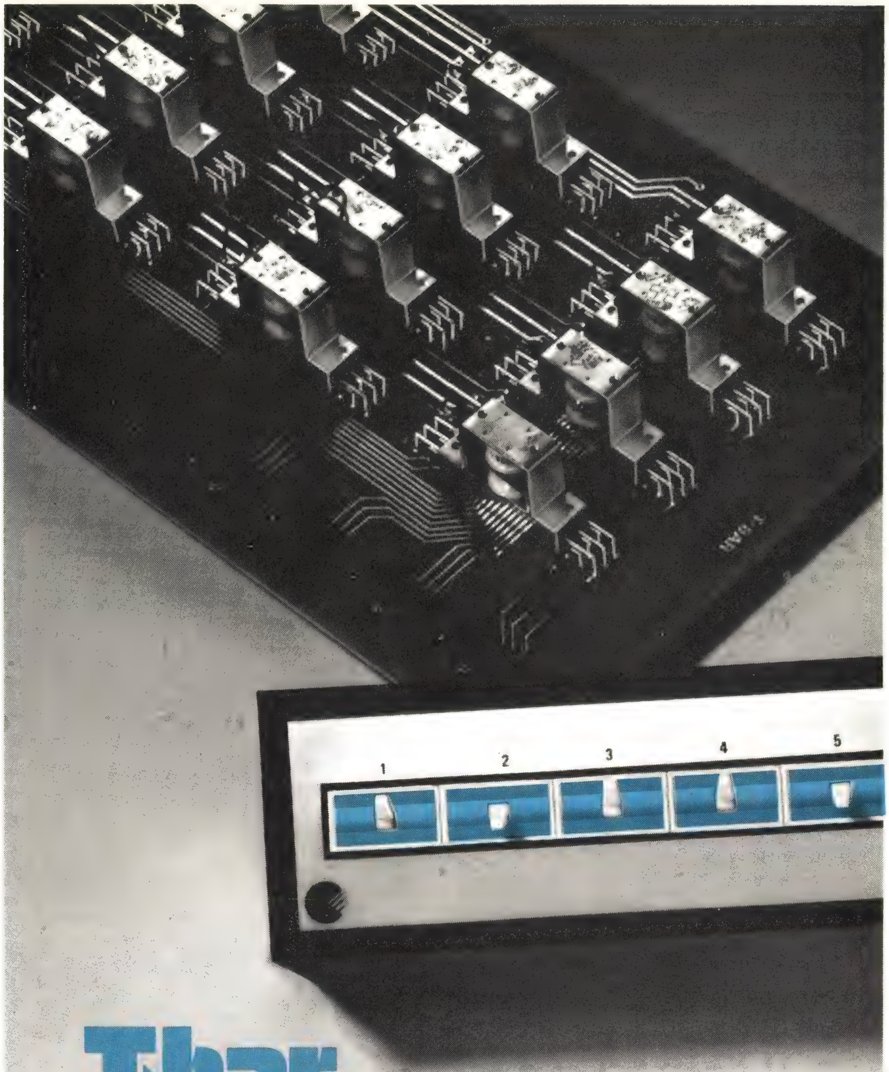
In a typical system, several peaks of, say, 750 to 1000 A occur, lasting for one-half cycle. Average inrush current is 780 A for as long as 2 s. Once this turn-on sequence is complete, the average running current in this particular system would be 128 A per phase.

However, the average running current of the system more than doubles for short periods of time when peripheral equipment is turned on. Therefore, current-limiting devices like ferroresonant transformers would have to be oversized to handle the turn-on requirements of these peripherals. Otherwise, the voltage output would collapse, dropping the voltage supplied to the computer so that it falls out-of-spec during the turn-on sequence.

High Zo cuts voltage

High output impedance is also a problem during turn-on. Power conditioners using the saturable core reactor designs may suddenly drop the voltage presented to the computer to 75% of the rated value, for several cycles of line frequency. Once again, power to the computer will be out-of-spec during that time period.

Even if ferroresonant devices and saturable-core reactors prevented transmission line transients from affecting the computer, the normal sequence of operations of the computer would create other problems. Both ferroresonant and saturable-core reactor devices are adversely affected by nonresistive loads. Both present low voltages to a 0.8 lagging power factor. ■■



T-bar®

Reliability

6 Pole Double Throw Miniatures

T-Bar's new 200 Series of Miniature Relays and Switches with gold contacts are specifically designed for switching low level Analog, Digital and Video data signals in Communications, Computer, Telephone and Test Equipment applications. Miniatures . . . another series of reliable switching products from T-Bar. Want to know more . . . Call or write T-Bar today.

T-bar® INCORPORATED
SWITCHING COMPONENTS DIVISION
141 Danbury Rd.
Wilton, CT 06897
203 762-8351

CIRCLE NUMBER 95

We'll help you see infra-red and put you on target as well.

As manufacturers of the widest range of broadband infra-red detectors in Europe we offer designers an extensive range of devices to suit virtually all their project requirements.

So, whether you're involved in infra-red detection for industrial, military or research applications in any of these fields, things are looking better for you:

- Gas analysis
- Laser detection and measurement
- Intruder and fire alarms
- Radiometry and spectroscopy

Plessey infra-red detectors feature a range of element materials: ceramic, lithium tantalate, triglycine sulphate; a choice of windows and filters for selecting spectral response and a choice of electronics to give the required signal response.

And, if your need is for fast photovoltaic detectors for CO_2 laser range-finding applications, we can also offer lead tin telluride in the 10-11 micron region. High $D^*(4 \times 10^{10} \mathrm{cmHz}^{\frac{1}{2}}\mathrm{W}^{-1} \lambda p, 800, 1)$ bandwith to 10MHz and beyond.

Whatever your requirements, ask for our latest catalogue to put you on target.

PLESSEY

Plessey Optoelectronics and Microwave Limited
Wood Burcote Way, Towcester, Northants, United Kingdom NN12 7JN.
Telephone: (0327) 51871 Telex: 311442
Plessey Optoelectronics and Microwave Limited
1641 Kaiser Avenue, Irving, California 92714, USA.
Telephone: (714) 540 9934 TWX: 910 595 1930

0632 2 0010

CIRCLE NUMBER 150

Electronic Design
INTERNATIONAL

Feb. 15, 1980

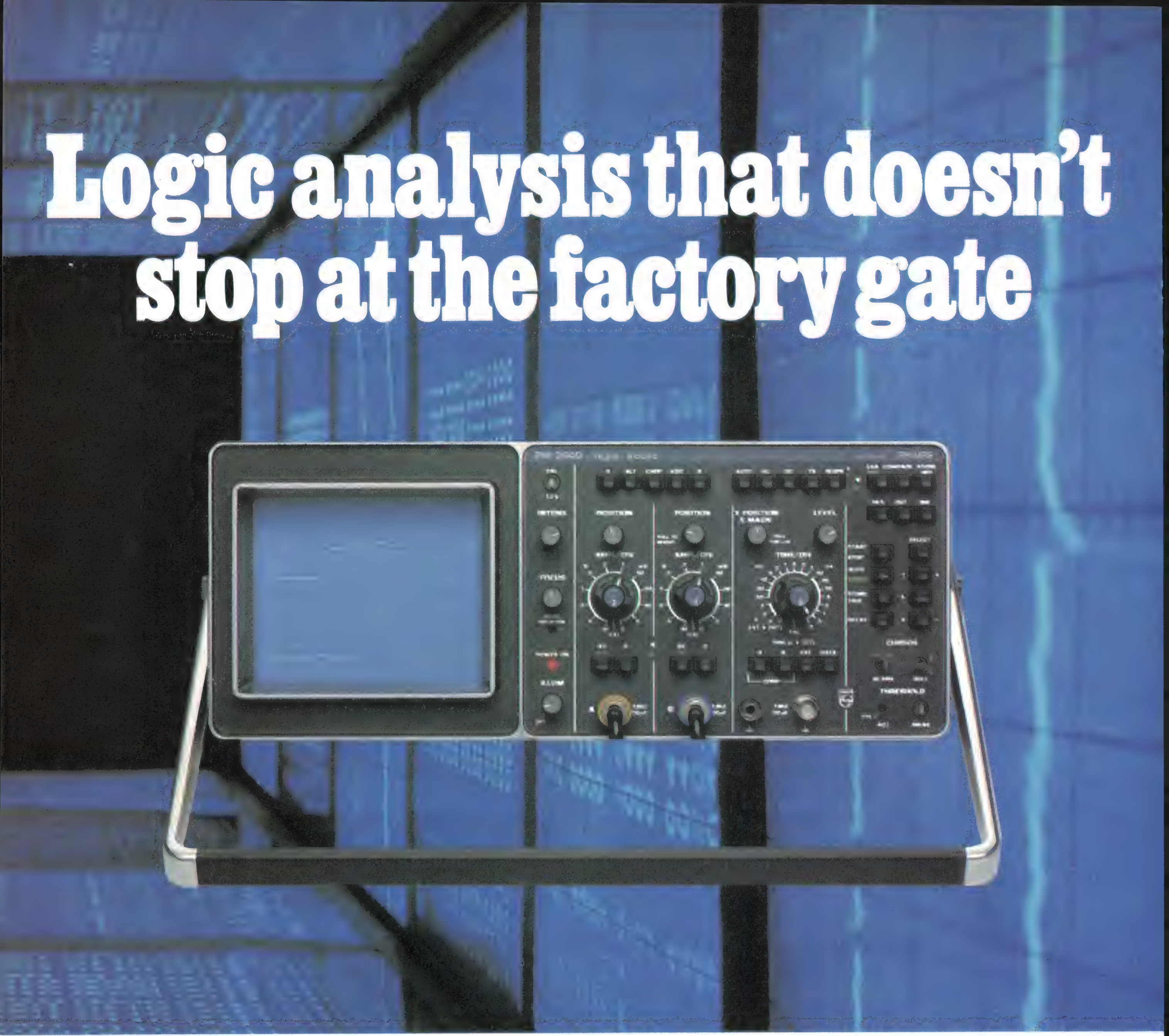
A first: 16-bit μC fits on one Eurocard

Universal programmer tightens temp control

Indicator measures liquid levels ultrasonically

Hygrometers give accurate, digital readouts

Logic analysis that doesn't stop at the factory gate

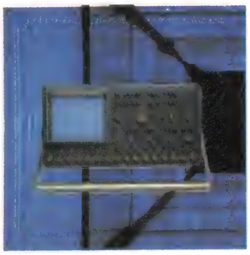


Logic analysis doesn't stop when digits leave designers' hands. Like analog volts and amps, it follows the product... through development and test... and on into maintenance and service... areas well outside the factory gate, where digital trouble shooting used to be a big problem. Used to be, because our PM 3540 has been specifically designed to meet *all* these needs... from development through field service.

The PM 3540 is the only compact instrument that allows data to be displayed, analysed and then be directly related to real-time situations. At the touch of a button the PM 3540 changes from a *logic analyser* to a two-channel *oscilloscope,* with interactive triggering from the same data word, giving an *exact* cross reference between data and timing; an essential requirement for digital trouble shooting. You can work with data in binary, octal or hexadecimal formats... capture a data block of 64x16 bits anywhere along the data stream... page the display at the touch of a button through the data stream... analyse and track down the fault and then set the PM 3540 to trigger, internally, as an oscilloscope.

The versatile PM 3540 also features dedicated logic probes, with a long list of significant benefits, plus excellent performance as a dual-trace oscilloscope in its own right. Literally the best of both worlds ... logic and real-time analysis... in a single, compact, high-performance instrument.

Philips Industries,
Test & Measuring Instruments
Dept., TQ III-2-51,
Eindhoven, The Netherlands



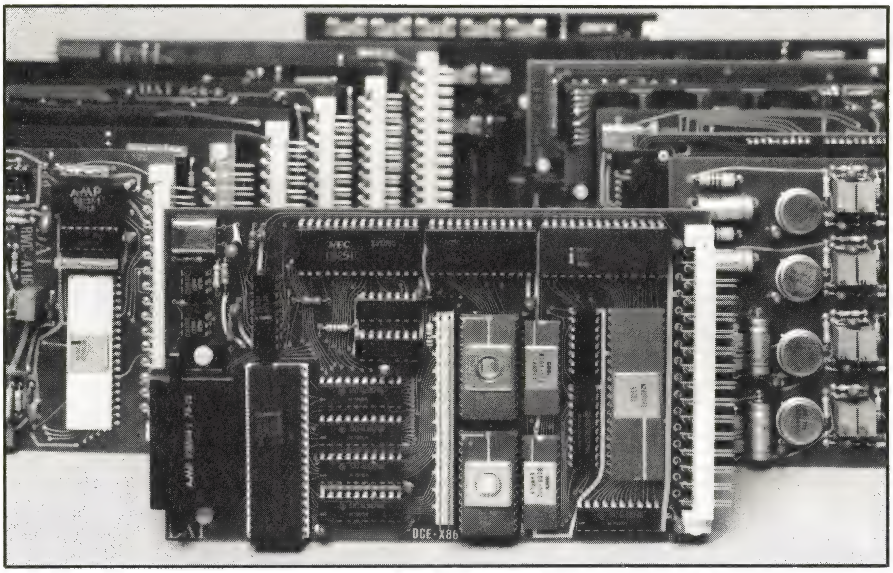
PM 3500: our other versatile logic analyser for design and development

Test & Measuring Instruments

CIRCLE NUMBER 194

PHILIPS

A first: 16-bit microcomputer on a single Eurocard



Data Applications International SA, Dreve des Renards 6 Box 8, 1180 Brussels, Belgium. (02) 375-1114. Telex: 61067.

The DCE-X86 16-bit microcomputer from DAI is the first to be completely contained on a single 160 × 100-mm Eurocard. Based on the 8086 CPU, the microcomputer comes with 4 kwords of EPROM memory, 1 kword of RAM memory, optically isolated serial I/O, three programmable 8-bit parallel ports, two programmable 16-bit interval timers, and a programmable interrupt controller.

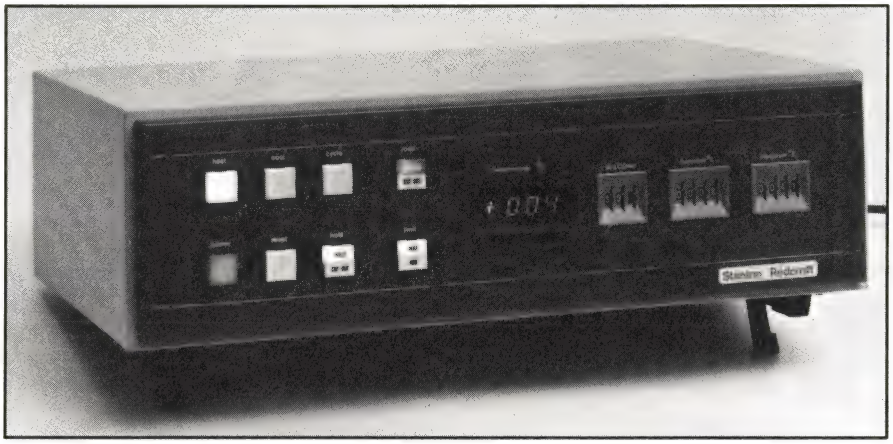
The serial-I/O channel provides synchronous or asynchronous operation with programmable baud rates. (In addition, the DCE-X86 can be interrupt-driven.) A range of standard serial-interface cables allows direct connection to almost every type of serial device.

A flat-cable connector on the card helps link the DCE-X86 to DAI's range of memory-expansion modules. Up to 64 kwords of external memory can be added, and DAI offers EPROM, RAM, and CMOS RAM cards.

What's more, the microcomputer is bus-compatible with DAI's line of "real-world" interface modules—currently 40—which can be interfaced via the DCE bus. Real-world interface cards include analog and digital I/O, relay outputs, optoisolated inputs, matrix interfaces, scientific-math modules, and medium and high-current drivers. A comprehensive range of hardware accessories is available.

CIRCLE NO. 501

Universal programmer gives accurate temperature control



Stanton Redcroft (Div. of Oertling Ltd.), Copper Mill Lane, London SW17 OBN, England. (01) 946-7731. Telex: 8811417.

An all-electronic universal temperature programmer (UTP) from Stanton Redcroft provides accurate control of temperature and other parameters. Being fully electronic, it is unencumbered by cams or other mechanical parts that could fail or lose accuracy. It is especially useful for thermal testing and other applications requiring linear variations with time.

Operation is controlled and results are displayed digitally. A three-digit readout displays the actual temperature to within ±1 digit. Thumbwheel switches set the maximum and minimum temperatures and the slope of the linear ramp. Binary-coded-decimal electrical outputs allow the temperature to be processed by a computer or desktop calculator, or recorded. The heating rates can also be programmed by external equipment. Pushbutton switches select the operating mode and provide a choice of temperature-cycling programs.

Because the output is totally isolated from the programmer circuits, and because there is a wide choice of output options, the UTP can be used with various electrically driven furnaces and heat chambers to suit a wide range of applications.

Various options cover a total temperature range of −200 C to +1500 C. A 100-Ω platinum-resistance sensor can be used from −200 C to +500 C. A chromel-alumel thermocouple covers 0 to 1000 C, while a special rhodium-platinum thermocouple works as high as 1500 C. All units are provided with thermosensor-break protection and automatic cold-junction compensation, which cover 0 to 50 C.

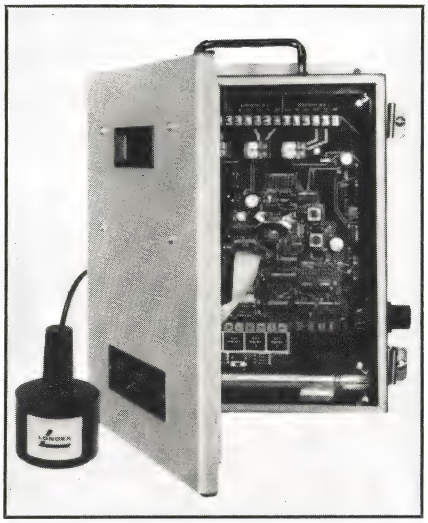
CIRCLE NO. 502

μC-based indicator measures liquid levels ultrasonically

Londex Ltd., P.O. Box 79, Oakfield Rd., London SE20 8EW, England. (01) 859-2424. Telex: 262716.

A digital level indicator from Londex combines the accuracy of ultrasonic level measurement with the flexibility of a microcomputer. The result is a versatile fluid-level monitor that requires no calibration during installation, yet indicates levels with an accuracy of 0.1%.

What's more, because the sensor doesn't touch the fluid, the instrument measures the levels of all types of liquids. It can even handle such difficult-to-monitor liquids as solid-content, high-viscosity and corrosive-action types.



A four-digit LED display gives a bright and legible readout of liquid levels.The full-scale range is 3.66 m (12 ft) with a resolution of 1 mm. Three analog electrical outputs, provided with the standard unit, can be used for proportional control and to drive remote meters or recorders. The basic unit also includes three separate control relays, which can be adjusted to operate alarms or control valves.

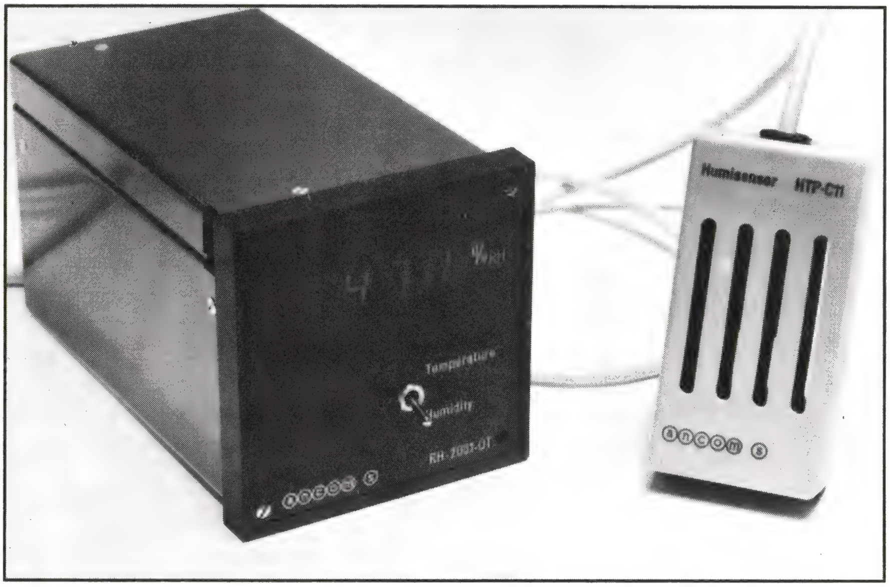
The self-calibration capability is especially useful in applications where the speed of sound is likely to change because of wide temperature variations. An alternative sensor then provides a reference for automatic recalibration. In addition, the built-in microcomputer enables the instrument to be set up for a wide range of applications quickly and easily.

Decade switches allow rapid presetting of measurement span, set points, time delay and even the unit of measurement—in meters, centimeters, feet, inches or percents.

No calibration or troubleshooting instruments are required during installation because LED indicators show when the unit is functioning correctly. Thus, the only equipment needed is a simple screwdriver.

CIRCLE NO. 503

Accurate, stable systems measure humidity and temperature



Ancom Ltd., Devonshire St., Cheltenham, Gloucestershire GL50 3LT, England. (0242) 53861.

Two series of electronic hygrometers, RH2000DT and RH2100DT, help build accurate and stable systems for measuring relative humidity and temperature. Made by Ancom, the hygrometers have digital readouts and outputs—making them suitable for computer-based instrumentation and control systems.

In measuring relative humidity, the instruments have an accuracy of ±1% or ±3%—depending on the sensor used. With a suitable sensor, the accuracy of temperature measurements is 0.1%. Overall system accuracy is 2%, with an instrument and probe having 1% accuracy. The hygrometers have excellent long-term stability and require recalibration only once a year.

Together, the RH2000DT and RH2100DT instruments cover a practical range of 10 to 95% relative humidity and a temperature range of −40 to +90°C. The 2000 series is designed for measurements in the 10 to 40% RH range, and the 2100 series for 30 to 100% RH. Both RH and temperature are displayed by 3-1/2-digit, 11-mm LED readouts for daylight viewing.

Two types of humidity sensors will work in these systems. The Humisensor HTPC-111 provides an accuracy of 1%; the HTPC-113 is a 3% unit, which includes a platinum resistance bulb.

For humidity measurements, a negative-temperature-coefficient (NTC) element senses changes in relative humidity. The sensitive portion of the NTC element, on the outside surface of the sensor, adsorbs water from the atmosphere. This adsorption technique provides relatively fast response times—approximately 30 s in still air for a change of 63% RH. Furthermore, the element is unaffected by most other environmental conditions.

CIRCLE NO. 504

Would you want to know us if we weren't so successful?

Over 100,000 Gould MG switching power supplies are in use throughout the UK and Europe every day, operating with such reliability that it would be easy to forget exactly who helps your systems and products work so well. You could say we're victims of our own success!

The Gould MG range of switching power supplies is made from carefully selected and tested components of the highest quality, to give you optimum performance at all times. The calculated MTBF is 122,000 hours. A range of four different case sizes gives 100W to 500W output power from 5V, 12V, 15V or 24V outputs. Gould MG power supplies are approved to UL478 and designed to meet the requirements of VDE0875, VDE0804, BS800 and CEE15. They are available for operation from 115/220/240Vac supplies.

Can you really afford to forget us? Would we offer you a five year no quibble guarantee if we weren't so successful?

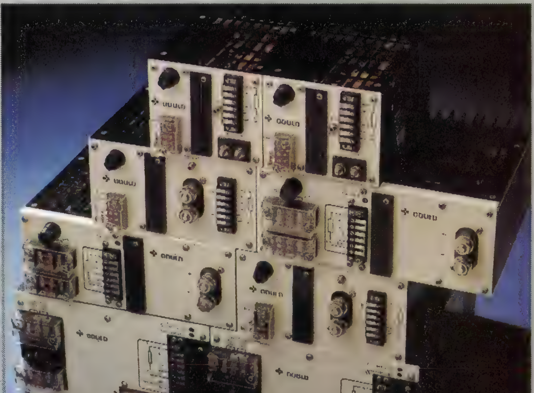
Gould Electronic Power Supply Division,
Raynham Road, Bishops Stortford,
Hertfordshire CM23 5PF.
Telephone: (0279) 55155 Telex: 81510

GOULD

An Electrical/Electronics Company

TIB 1/80

CIRCLE NUMBER 195



We know how

to build-up a 480 lane main route

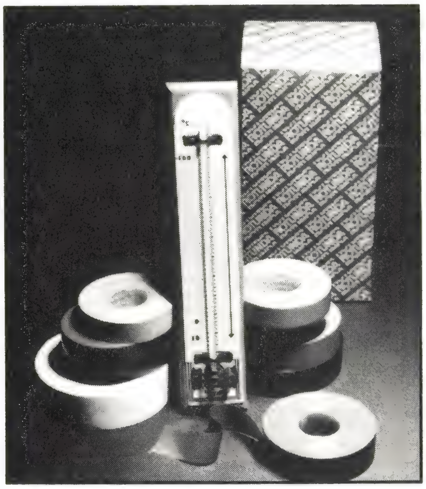
...and how you can cruise on it
at 34,368 kbit/s speed
Italtel's PCM multiplex: a range of systems
containing all the answers
to all the problems in digital transmissions.
CIRCLE NUMBER 196

SP 7291/04

ITALTEL
Telecommunications is our business

20149 Milan (Italy) - 12, Piazzale Zavattari - phone (+ 392) 4388.1

Insulating adhesive tape meets UL standards



Rotunda Ltd., Holland St., Denton, Manchester, Lancashire M34 3GH, England.

An all-weather PVC tape, type 2731, has been fully approved by the U.S. Underwriters' Laboratory. The insulating adhesive tape passed all four gradings of the UL standard for general properties, weather resistance, flame retardance, and resistance to low temperatures. Thus it has the highest UL rating for PVC tape. The flexible and conformable black tape has excellent electrical properties and is designed for continuous use at 80 C and for use at temperatures down to −10 C. It is produced in nine widths from 12 to 75 mm, and in 10, 20 and 33-m roll lengths. The tape also conforms to British standards BS 3J-10 and BS 3924 (31/90). It can also be supplied to meet the Scandinavian NEMKO standard.

CIRCLE NO. 505

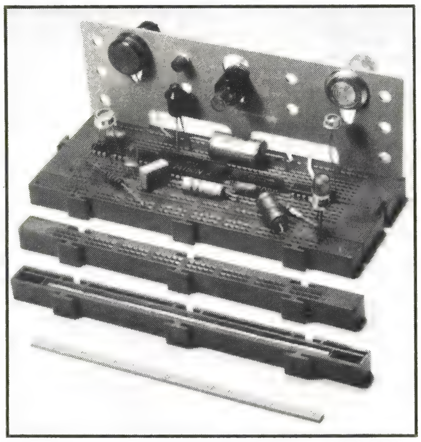
Pressure transducers fit flush to the diaphragm

Bell & Howell Ltd., Lennox Rd., Basingstoke, Hampshire RG22 4AW, England, Basingstoke (0256) 20244. Telex: 858103.

Type 4-327 pressure transducers have a flush diaphragm, allowing them to be used without adding "dead volume" to the system. The result is maximum frequency response. The transducers lend themselves to all applications that preclude a cavity in front of the diaphragm. A flange provides flush surface mounting. Stainless-steel construction allows operation with corrosive fluids. Versions are available with completely waterproof flying leads or a detachable connector. Transducers are available in pressure ranges from 0-0.75 to 0-100 bar. Crevice-free versions are available for hygenic applications.

CIRCLE NO. 506

New part expands scope of breadboard system



Boss Industrial Mouldings Ltd., Higgs Industrial Estate, 2 Herne Hill Road, London SE24 OAU, England. (01) 737-2383.

A two-line Bus-strip augments the existing Bimboard system of DIP-compatible breadboards. The new part is for use where the two existing integral rails of a Bimboard are insufficient for the particular circuit to be breadboarded. The Bus-strip employs the same robust interlocking scheme currently used for joining Bimboards together in any direction. Therefore, it slots into any edge of single or multiple boards. The Bus-strip has a pitch of 0.1 in., and accepts components with lead diameters between 0.25 and 0.85 mm. Typical contact resistance is 10 mΩ at 1 A, and contact-to-contact capacitance is 0.5 pF.

CIRCLE NO. 507

Low-cost universal unit programs all PROM types

Digitronics Israel Ltd., 3 Tevuot Haaretz St., P.O. Box 39821, Tel-Aviv, Israel. 4 720 10. Telex: 33343.

A low-cost universal programmer, UPP-801, has personality modules and device interface sockets for use with any commercially available PROM device—including EPROMs, bipolar PROMs, EEPROMs, EAPROMs, and PAL. Data entry and editing can be done with keyboard entries in hexadecimal, BCD, octal or binary. Also, data can be entered from an internal or external paper-tape reader, or from other peripheral devices via an intelligent interface with up to 32 user-selectable codes and formats. Conversely, the programmer can output data to a peripheral device in preselected code. An optional gang module allows 10 different types of EPROMs to be handled without changing personality modules.

CIRCLE NO. 508

Instrument controller talks over IEEE-488 bus

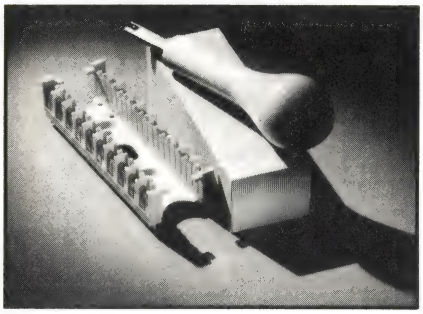
Systron-Donner Ltd., St. Mary's Road, Sydenham Industrial Estate, Leamington Spa, Warwickshire CV31 1QN, England (0926) 35411. Telex: 311008.

The Model-3520 instrumentation controller is fully compatible with the IEEE-488 bus. Yet, it costs under £600, whereas competing systems costs up to £8000. The controller is easy to use. Operators without previous programming experience can be trained to program instruments via the bus within a few minutes. This is because special single keys on the 3520 are dedicated to IEEE-488 commands such as "Bus Clear," "Bus Address," "Bus Remote," "Bus Out," etc. On other controllers, these commands require the assembly of complicated program sequences. Programs can be assembled and stored within the 3520's internal memory. Also, they can be permanently stored on an external plug-in PROM cartridge. The software system, in addition to simple control, also allows arithmetic and relational operators, two-dimensional arrays, subroutines and immediate or deferred modes of operation. The controller works with a wide-range of bus-compatible instruments.

CIRCLE NO. 509

International New Products

Terminal block allows quick phone hookup



LM Ericsson Telematerial AB, Box 401, S-135 24 Tyreso, Sweden. (08) 742-4000. Telex: 10920.

Intended for telecommunications applications, the NER 201-01 quick-connect terminal block requires no soldering and has no screws. It fully conforms to Swedish (SEN) electrotechnical standards. The 10-pair unit can be fixed to indoor racks or walls, and functions as both a cross-connection block and distribution box. With a U-shaped cross section, the orange thermoplastic body is formed like a cable duct. The walls of the block have ten pairs of slotted terminals, and each terminal has two slots—for incoming and outgoing wires. Wire diameters are 0.5 to 0.7 mm. A special tool, LSY 13801, secures the wire in the slot and snips off the excess. No wire-end stripping is needed.

CIRCLE NO. 510

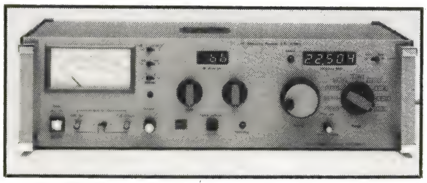
Urethane materials offer wide range of properties

Emerson & Cuming (UK) Ltd., Colville Rd., Acton, London W3, England. (01) 992-6692.

The Eccothane line of low-cost urethanes meets a variety of industrial requirements. Among the first materials to be included in the new line are a series of two-part filled materials which can be cured in 24 to 48 h at room temperature, or in 1 h at 200 F (93 C). Six different products are available in the Eccothane line. Eccothane 40 is a flexible, unfilled polyurethane which can be cured to a tough, abrasion-resistant, resilient material. Eccothane 43 can be cured to a tough and resilient material, and has better thermal conductivity than most polyurethanes. Eccothane 44 is a more flexible version of the Eccothane 54 casting system. Eccothane 50 is a harder and stronger version of Eccothane 40. Eccothane 53 is a thermally conductive system similar to Eccothane 43 but with much better tensile and tear strengths.

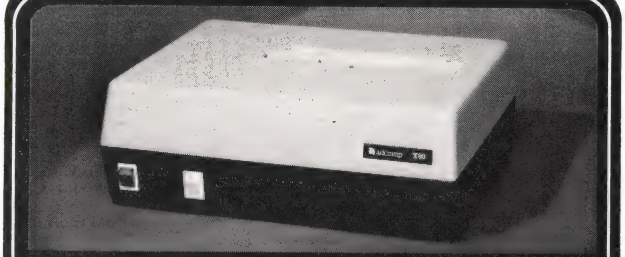
CIRCLE NO. 511

Field strength meter covers broadcast bands



Chase Electrics Ltd., Church Lane, Teddington, Middlesex TW11 8PA, England. (01) 977-0251.

The Type NBR-2010 field strength meter is a derivative of Chase's suc-



X50/X80

Alpha-numeric printers for normal paper

- V24 (RS 232 c) Interface
- Parallel Interface
- IEC Interface for PET 2001/3001

Hobby·Commerce·Industry·Science

- Printspeed 100 characters/sec. (bidirectional)
- 5 x 7 Matrix
- High reliability
- 52 or 80 characters per line
- ASCII-Signs

Agents wanted outside Germany!

d&m 609

adcomp

Datensysteme GmbH · Horemansstraße 8
8000 München 19 · Telefon 089/19 40 19

CIRCLE NUMBER 197

Canned Lightning

This component tames uncontrolled surge voltages with lightning speed by a controlled little lightning in its inner.

Reliable protection for sophisticated electric devices and Telecom equipment against overvoltages by thunderstorms or other causes.

Gas Discharge Arrester

Further details you will find in our leaflet S 4.

A mark of safety

Wickmann-Werke AG

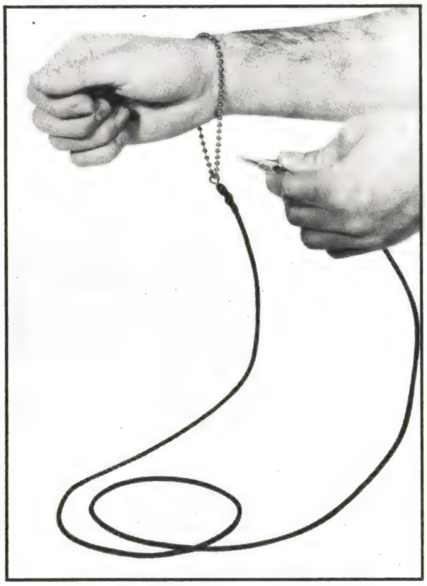
Annenstraße 113 · D-5810 Witten 6 · Abt. SF
Tel. (0 23 02) 66 21 · Telex 08 229 145

CIRCLE NUMBER 198

cessful Type HFR-2000 interference measuring receiver. It has been primarily designed for measurement of broadcast field strengths in the frequency range of 150 kHz to 30 MHz. The instrument features automatic calibration and internal locking. Both frequency and amplitude are displayed on digital readouts. Results and settings are also available in the form of BCD-coded electrical outputs. In addition to the digital amplitude display in decibels, there is an analog meter with both linear and logarithmic scales.

CIRCLE NO. 512

Wrist strap prevents electrostatic damage



Surrey Electro Materials Ltd., Surrey House, London Rd., Staines, Middlesex TW18 4HW, England.

Called the Mark III Westrap, a conductive wrist strap prevents electrostatic damage to integrated circuits during assembly, handling or inspection. Because it uses no materials that can slough off or otherwise contaminate an ultra-clean environment, it is especially suited to use in clean rooms. A beaded chrome-plated steel chain around the wrist drains static electricity from the worker's body before it can build up to harmful levels. A 4-ft. flexible rubber-covered wire, fitted with an alligator clip, runs electricity from the wrist chain to any convenient ground. A resistor built into the wire prevents electrical shock if the wrist strap should contact a live wire.

CIRCLE NO. 513

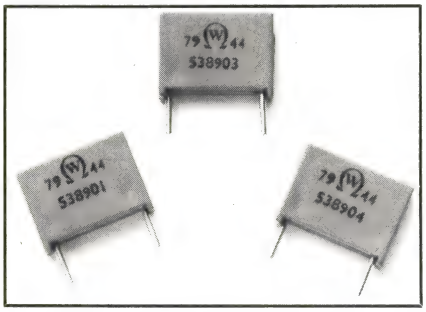
Electronic stop watch can be remote controlled

McMurdo, Rodney Rd., Portsmouth, Hants P04 8SG, England. Portsmouth (0705) 735361.

Electronic timers in the Multitimer 610 series are crystal controlled. The timers measure time to an accuracy of 99.999% over a temperature range of −5 to +45 C. The instruments have "start/stop" and "hold" controls which can be operated manually or by remote devices such as snap-action switches, photoelectric switches or relay contacts. A "hold/rejoin" facility allows a time to be frozen and read while total time is still running. Further action of the "hold/rejoin" switch returns the display to the running time. The "reset" switch returns the display to zero. Times are shown on a six-digit, 12.5-mm, liquid-crystal display. Measurements can be made over ranges of either 10 min or 1 h. The resolution is 1/1000 s. or 1/100 s, respectively, Powered by a self-contained 9-V battery, or by an external 9 to 12-V supply, the compact instrument weighs only 500 g.

CIRCLE NO. 514

Spark gaps protect electronic components



Welwyn Electric Ltd., Bedlington, Northumberland NE22 7AA, England. Bedlington (0670) 822181. Telex: 53514.

The 5389 series of small spark gaps is designed to handle medium energy discharges at relatively high voltages. The spark gaps are widely useful for the protection of expensive components in electronic circuits—important examples include cathode-ray and video-display tubes. Because the spark gaps are totally enclosed but not hermetically sealed, they avoid contamination from dust but remain at atmosphere pressure as the ambient temperature changes. This improves their operating repeatability. Normal variations in atmospheric pressure have very little effect on discharge voltage, but a significant change in discharge voltage could be caused by pressure changes due to temperature fluctuation in a sealed device. Rated dc discharge voltages range from 7 kV to 12 kV. All devices in the series have an insulation resistance of 10^{12} Ω at 100 V dc, and a maximum capacitance of 2 pF. Peak discharge currents range from 1 kA for the highest voltage spark gaps to 1.5 kA for the lower voltage devices. The flat cases are flame retardant to BS415-14/4 and have tinned leads for mounting on PC boards.

CIRCLE NO. 515

Tough hand tool cuts and strips cables

Cliff Electronic Components Ltd., 24 Hillcrest, The Mount, Coulsdon, Surrey CR3 2 PR, England. (01) 668-0031. Telex: 8813346.

The PTS-2 cable cutter/stripper is molded from glass-filled polyamide material, making it tough and light weight. The inexpensive hand tool strips PVC cables from 1-mm to 6-mm diameter with just a squeeze of the handles. The tool adjusts itself to all cable sizes. Since the cutting blades never contact the conductors, no strands of copper can be accidentally cut. Spare cutting blades, supplied with the tool, extend its life indefinitely.

CIRCLE NO. 516

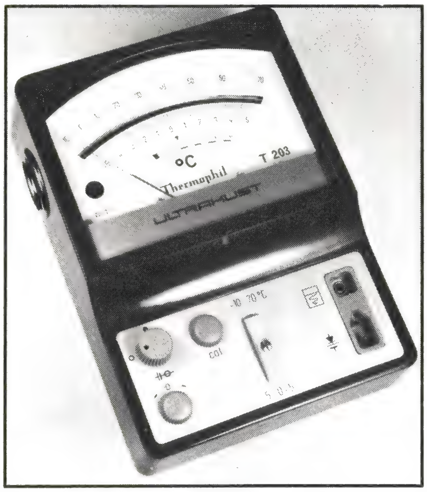
Fiber-optic cables come with connectors

Burr-Brown International Ltd., Cassiobury House, 11-19 Station Rd., Watford, Hertfordshire WD1 1EA, England. Watford (0923) 33837. Telex 922481.

Three types of fiber-optic cable assemblies, OCA 100, 101 and 102, are terminated with AMP Optimate single-positon connectors. The OCA 100 series is fully compatible with Burr-Brown's 3712 and 3713 fiber-optic transmitters and receivers. This plastic, general-purpose cable has a fiber diameter of 1016 μm and a total cable diameter of 2.2 mm. With an attenuation of 1300 dB/km, it offers the best compromise between price and performance for short lengths. The OCA 101 is also constructed of plastic, but has an optical fiber of only 400 μm in diameter. The protective covering consists of an inner and outer jacket, both made of Hytrel, and a layer of reinforcing Kevlar-49 fibers between the inner jacket and optical fiber. The attenuation of this cable at a wavelength of 660 nm is only 360 dB/km. This makes it usable in lengths of up to 90 m. The OCA 102 is a plastic-clad, silica-fiber assembly. Its single 200-μm fiber is protected by two Hytrel plastic jackets and Kevlar-49 reinforcement to form a rugged cable. Its low attenuation of 33 dB/km at 660 nm wavelength allows run lengths of over 850 m when used with the 3713T transmitter and 3712R receiver.

CIRCLE NO. 517

Electronic thermometer measures without contact



Ultrakust-Gerätebau GmbH, Postfach 20, D-8375 Ruhmannsfelden, Federal Republic of Germany. (09929) 1322. Telex: 069124.

A temperature measuring instrument, Thermophil T203, finds the temperature of a wall or other surface—without contact—in less than 1 s. It was originally designed for the building industry to test thermal-insulation effectiveness to the DIN-4701 standard. It measures temperatures over a range of −10 to +70 C. Powered by an internal 9-V battery, it can also be line operated with a battery charger. Fast relative measurements are achieved with a resolution of 0.1 K over a range of ± 5 K. A built in "black-body source" standardizes the measurements. A recorder output of 1-V full scale at 5 kΩ, allows permanent records of measured

Z-80
EMULATOR
Micro Processor Test Equipment

- Real time trace memory
- Built in diagnostic and test loops
- User programable diagnostics
- Portable stand-alone emulation

Engineering Development
Hardware and Program De-Bugging
Production Testing
Functional Test and Trouble Shooting
Field Servicing
Trouble Shooting and Field Engineering

APPLIED MICROSYSTEMS 11064 118th PL N.E. KIRKLAND, WA 98033
FOR INFORMATION CALL (206) 827-9111

CIRCLE NUMBER 199

temperature. The instrument finds surface temperature by measuring infrared radiation. Because there is no contact with the surface under test, there is no heat loss to cause measurement errors.

CIRCLE NO. 518

Switching supplies have low ripple and low RFI

Melcher Electronics, Seestrasse, CH-8610 Uster, Switzerland.

Primary-switched 30-W power supplies in the LSR-30 family have been designed to produce low ripple and low RFI. The input filter reduces RFI to less than level K of the VDE-0871 specification. A specially-designed output filter holds ripple to less than 5 mV pk-pk for the 5-V, 6-A unit. Supplies operate from 110/220 V ac ±20% or from 220 to 372 V dc. Standard output voltages are 5, 12, 15 and 24 V dc. All units are designed to withstand continuous short-circuit and no-load conditions. A second control loop provides overvoltage protection. Operation is guaranteed for case temperatures from −25 to +85 C; no derating is necessary within the working range. The modular version measures 40 × 111 × 170 mm. A rack-mounting version, with a 45-mm panel, is compatible with standard 19-in. racks.

CIRCLE NO. 519

Single-board μC uses fast bipolar processor

N. V. Philips Gloeilampenfabrieken, Elcoma Div., P.O. Box 523, 5600 AM Eindhoven, The Netherlands. Telex: 51573.

A single-board microcomputer, 8X300DMS2KMC, uses an 8X300 bipolar microprocessor and associated components. A cycle time of 250 ns and architectural features of the 8X300 make this the fastest microcomputer with a fixed instruction set. Up to 2 kwords of program storage are provided on the board. Eight bidirectional 8-bit I/O ports form a total of 64 I/O lines. The microcomputer is supported by a development and monitoring system (8X300DMS1KBB). Occupying a double Eurocard (233 × 160 mm), the microcomputer needs just a single 5-V power supply. A diagnostic program on punched paper tape is available. An optional support board (8X300DMS3KAS) has a resident assembler and an additional 3 kwords of program storage.

CIRCLE NO. 520

Planetary gearbox works with servo motors

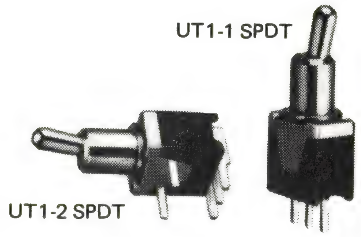
Portescap, CH-2300 La Chaux-de-Fonds, Switzerland. (039) 211141. Telex: 35266.

A precision planetary gearbox, R22, has a torque rating of 0.6 N-m (85 oz-in.). It can be fitted to Portescap's Escap servo motors type 22, 23, 26 and 28PL. Two or three gear stages provide six different ratios from 16.2:1 to 190:1. Use of both plastic and metal materials provides relatively low cost and good torque/volume ratios. The gearbox has a diameter of 22 mm and a length of 32.5 mm for ratios up to 33.1:1. For higher ratios, the length is 40 mm. Mounting is by three M2 tapped holes on the front plate.

CIRCLE NO. 521

PC MOUNTABLE MINIATURE SWITCH AT MODERATE COST

U series—100 types



- Our UT series (toggle, slide and push-button) was developed, with printed circuit in mind, for the application of dry circuit. Our one step ahead engineering study made it possible to realize a unique construction of switches, providing thicker gold plating on contacts other than the rest part of terminals.
- The contacts and terminals are 1.30 microns (min.) gold plated over 3.0 microns nickel.
- Economical version is also available at 0.5 microns Au.
- Case material is of high temperature, high impact and chemicals Valox, 94V–0 U/L.

Specifications:

Rating : 5V DC 100 mA
25V DC 25 mA
Contact Resistance
: Less than 20m ohm at 100 mV 1 mA DC.
Insulation Resistance
: More than 1000M ohm at 100V DC.
Insulation Voltage
: 500 DC for 1 minute.
Electrical Life : 2 Pos. 3 Pos.
50,000 25,000
(40,000 20,000 ... Economical Version)

Whole switches supplier

JEPICO

DIP, toggle, push, slide, etc.

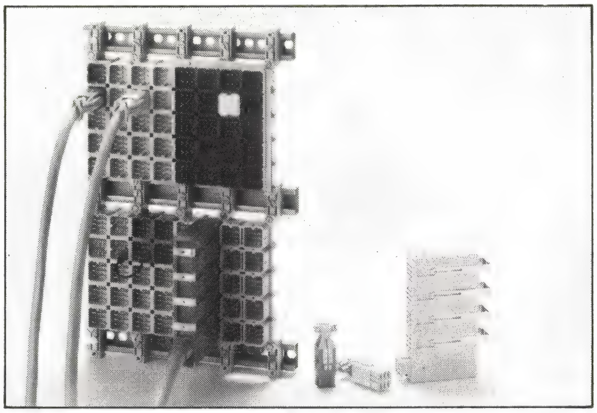
JEPICO CORPORATION
Overseas marketing section
Sagami Bldg., Shinjuku 4-2-21,
Shinjuku-ku, Tokyo, Japan
Telex: 2323167 Jepico J

CIRCLE NUMBER 201

Zeus needed no arguments to get Europa to yield.

Yes indeed – Zeus had "fabulous" ways of achieving his target.

But we do not have it so easy. We do need arguments. Sound arguments to win the confidence of European industry. As producers of electrical and electronic components we are judged by the quality of our work. And by our ability to solve problems and to develop vital new hardware.



Such as: VS 3000 – the new distribution and connection system.

Here for the first time a system is presented with which to standardize the wiring and cabling connections of measuring, control and regulating aggregates both to each other and to the switchboard control centres.

It comprises square, 6-pin elements with a contacting principle based on the universally used 6.3 x 0.8 mm flat plug and the A 6.3 pin bushing as per DIN 46340. On the building block principle these can be joined to form connector fields of I, I/H and U elements, e.g. shunting fields for connections on one or two wiring levels perhaps cabled with 30-pin multiple plugs.

The system is compact. Thanks to encodable elements, it is easy to handle and guarantees practically error-free operation and ease of maintenance. Furthermore, the elements offer the possibility of using different connecting techniques on the two wiring levels.

It is definitely worth your finding out more about this system. We, or our agents, will be glad to put you ahead on information.

HARTING ELEKTRONIK GmbH
Postfach 1140 D-4992 Espelkamp
☎ (0 57 72) 47-1
Tx 09 72 310 hrtng

HARTING

Belgium: B.V. Handelsmaatschappij BLESSING-ETRA, Division ELTORACO S.A.N.V., Bd. St. Michel 50 – 52, B-1040 Brüssel. **Denmark:** Knud Wexøe AS, Skaettekaeret 11, DK-2840 Holte. **Finland:** SKS Suomalainen Kone Oy, Kumpulantie 15, SF-00521 Helsinki 52. **France:** HARTING ELEKTRONIK S.A.R.L., BP 24, F-94120 Fontenay-Sous Bois Cedex. **Great Britain:** Klippon Electricals Ltd., Power Station Road, GB-Sheerness/Kent ME 12 3AB. **Italy:** Connectel S.R.L., Via Lincoln 7/C, I-20 092 Cinisello Balsamo (MI). **Netherland:** Jobarco B.V., Stephensonstraat 2, Ind. Gelände Zoeterhage, NL-2700 AD Zoetermeer. **Norway:** Henaco A/S, P.O. Box 248/Økern, N-Oslo 5. **Austria:** Burisch Ges. m.b.H. & Co. KG, Scheydgasse 31, A-1210 Wien. **Sweden:** Nordisk Elimport AB, Ljusnevägen 3, S-12161 Johanneshov. **Switzerland:** Interelectronic E. Oertli, Kirchenweg 5, CH-8032 Zürich. **Spain:** Elion S.A., Farell 9 – 11, 60, E-Barcelona 14. **Bulgaria, CSSR, Jugoslavia, Poland, Rumania, Hungaria:** Gebhard Balluff KG, Niederlassung Österreich, Kampstr. 1, A-2346 Maria Enzersdorf-Südstadt.

WÄCHTER BREMEN

CIRCLE NUMBER 202

Motorola Reports

- ☐ The 16-bit MPU that performs like a 32-bit machine
- ☐ Bargains in brute power
- ☐ The 64K memory world
- ☐ Custom LSI in 12 weeks
- ☐ Going octal in 488 pays off big
- ☐ Easiest systems from Micromodules

MC68000 single-board design aid

MOTOROLA INC.

Technological leadership.

Systems for the '80s need Motorola's MC68000, the 16-bit MPU that performs like a 32-bit machine.

Motorola's new MC68000, now in volume production, is a powerful microprocessor so advanced in concept that it offers designers an exciting new range of design freedom.

It's the only 16-bit microprocessor with many features of a 32-bit internal architecture, handling 8-, 16- and 32-bit operations. It operates with an easy-to-use set of 56 powerful instructions that, combined with its 14 addressing modes and five data types, provides maximum flexibility for users.

16-Megabyte memory address.

Internally, the MC68000 has eight 32-bit registers for data and seven for address, with 32-bit user and supervisory stack pointers supporting large word sizes and holding great promise for future systems. The 24-bit address bus permits a direct memory address capability of 16 megabytes (without segmentation), twice that of any other microprocessor.

All of the data and address registers can be used as index registers, and all address registers double as stack pointers to reduce the chances for programming bottlenecks. Separate address and data buses allow non-multiplexed asynchronous operation for an optimum mix of memory types and peripherals.

Peripheral interface is easy with M6800 family.

Compatibility with the entire M6800 family of synchronous peripherals is ensured by assignment of three special pins to control the many M6800 peripheral circuits which cover just about all your system requirements.

These include parallel interface, asynchronous communications interface, programmable timer module, CRT controller, floppy disk controller, video display generators, advanced data-link controller, synchronous serial data adapter and an IEEE-488 standard bus interface.

A new family of M68000 peripheral chips designed for the asynchronous 16-bit bus of the MC68000 will be introduced during 1980.

Get started with the Design Module.

Motorola's EXORciser® and EXORterm™ provide the necessary terminals for use with our new MEX68KDM, the design module that gets you working with the MC68000. It's a single board microcomputer system that enables users to evaluate application software on actual hardware, and examine the MC68000 architecture, instruction set and bus interface.

One of the most useful Design Module features is the debug monitor, named MACSbug™, which allows users to enter software programs from a terminal or from a host computer. It also allows the user to examine or change memory and control execution of the program. Over 40 commands are available in MACSbug.

We are also creating a completely new development system for both 16- and 32-bit microprocessors to stay ahead of advances in performance and architecture. . An advanced bus structure plus high performance software and hardware are key features of this upcoming third generation development system . . . EXORmacs.

MC68000 ideal for high-level languages. PASCAL is here now.

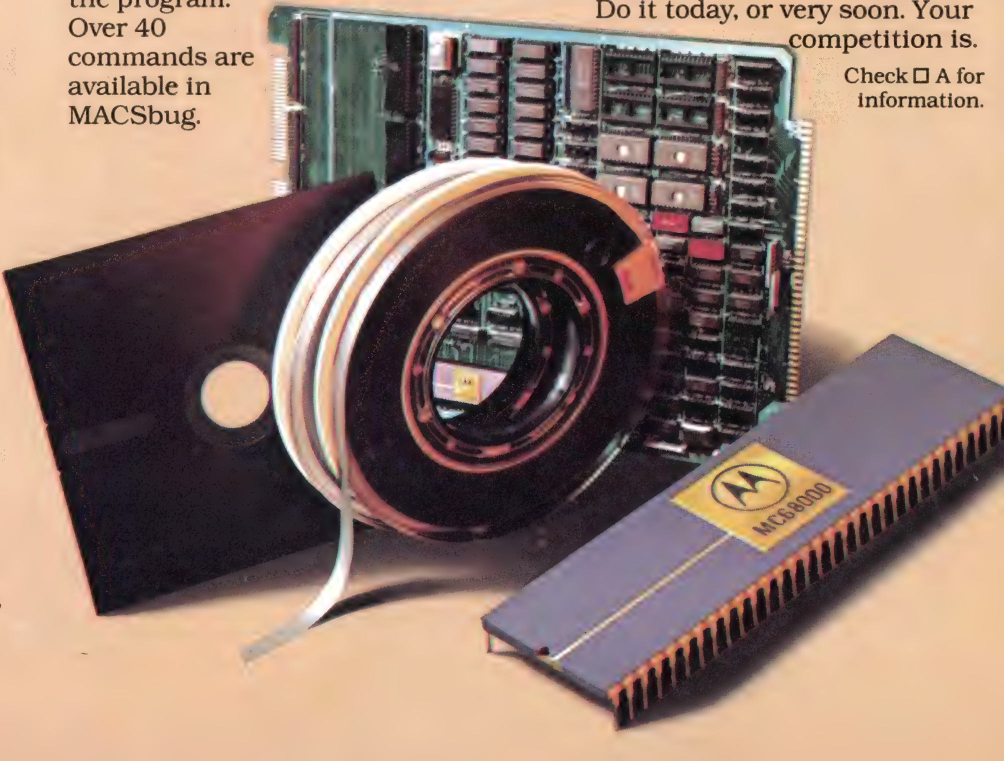
The MC68000 is just right for imaginative new systems because it's designed for high-level languages, specifically PASCAL. PASCAL's machine-independent software capability gives you the benefits of structured programming techniques, modularity, simplified debug, maintainability, and self-documentation.

A Cross-PASCAL compiler for the MC68000 is available now, and more PASCAL software will soon be introduced.

There are many more exciting aspects of the MC68000. The more you look, the more you find. You'll want to look deeper into the M68000 concept yourself.

Do it today, or very soon. Your competition is.

Check ☐ A for information.



provides a pragmatic picture of actual device operation under load conditions.

The MRF2016M is only $55, 100–up.

The MRF1000M/1150M series for short pulse power applications is specifically designed for drop-in replacement in existing DME/IFF and transponder sockets at significantly lower cost. These internally-matched, all-gold units offer industry-standard packages, compatibility and no-compromise performance at half the price.

The 150 W unit is just $45, 100–up.

Specials are available.

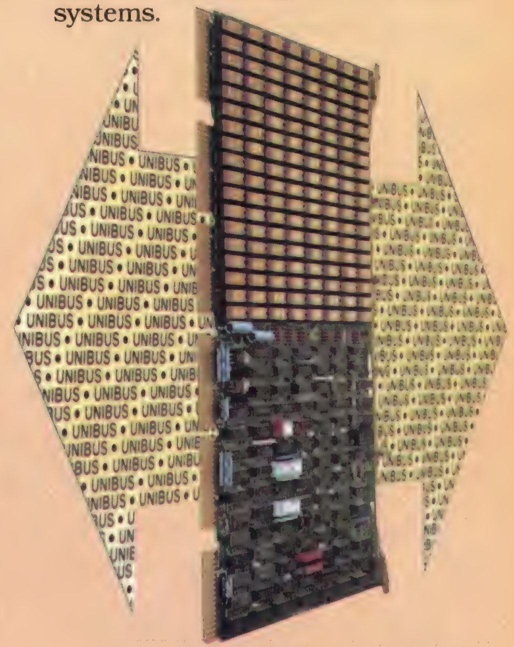
Check ☐ N for information.

Get leading-edge memory systems, from Motorola.

Our state-of-the-art MMS1119 Extended UNIBUS*-compatible add-in memory for PDP*11 systems is receiving most of the attention these days. Deservedly.

But, Motorola also offers a large variety of outstanding add-ins for most popular minis, microcomputer memories, and mass memory for large systems. Our expert design/production team is increasingly recognized for custom systems of all sizes.

Comprehensive warranty and factory service plans, full testing, 100% burn-in and engineering support in the field all contribute to the outstanding value of these systems.



Motorola add-ins are available for PDP11/03 through PDP11/60 minis in sizes ranging from 8K words to 128K words. Memories for LSI-11 systems are also available in the 8K word to 128K word size range.

Standard board-level memories for the General Automation 16/110 and 16/220 relieve availability pressures for that system. Others provide memory for SBC 80/10, 80/20, 86/12 and MDS† systems.

For leading edge storage, turn to Motorola.

*Trademark of Digital Equipment Corporation.

†Trademark of Intel Corporation.

Check ☐ R for information.

Listen, talk and save a lot with the one and only octal GPIB transceiver.

We've combined speed, low power and octal organization in the MC3447 GPIB transceiver and significantly cut your parts count, board space and cost.

Using a max of just 11.5 mA per channel (talk mode, all drivers on), the MC3447 hums along at 50 ns max prop delay with a fast, 30 ns channel to meet turnaround delay requirements of the protocol ATN and EOI signals.

And that's fast enough to meet virtually all of today's applications.

Its octal configuration means you get the job done with only two parts instead of four so you can group 16 bus lines in two groups of eight. Its internal, 4-1-1-1-1, enable and channel organizations are optimized so no added TTL is required.

You use just one part to cover both 8-bit slots in the 16-bit GPIB with no extra logic.

A new standard for 488.

Check ☐ Q for information.

60 A, 250 V Switchmode Darlington tames brute power control costs.

Motorola's unbeatable production technology has done it again—this time in high-current power for heavy, off-line use.

The MJ10020/21 SuperPower devices are 60 A (continuous), 90 A (peak), 200 and 250 V (sustaining) Switchmode Darlingtons with base-emiter speedup diodes. At $8.25 and $9.75 they're priced far less than the $30 to $40 comparables.

As Darlingtons, these units offer more performance per square mil of silicon than discretes. And as Switchmode devices, they provide the ultimate in specified performance. Each and every unit is specifically designed and characterized with solid, practical data from a pragmatic source . . . the Designers™ data sheet.

The MJ10020/21 are ideal for motor controls, switching regulators, inverters, solenoid and relay drivers, and deflection circuits or wherever thyristors or paralleled smaller transistors have been used.

The 250 W units offer 150 μA fall time.

Economy of scale allows us to offer glass-passivation for high-temp stability and 100% SOA testing for added assurance . . . without a premium price tag. Expect more from the SuperPower for your next high-power design.

And pay less for it.

Check ☐ E for information.

Building microcomputer systems with Micromodules is almost like child's play.

Designing and building a microcomputer system is certainly *not* child's play.

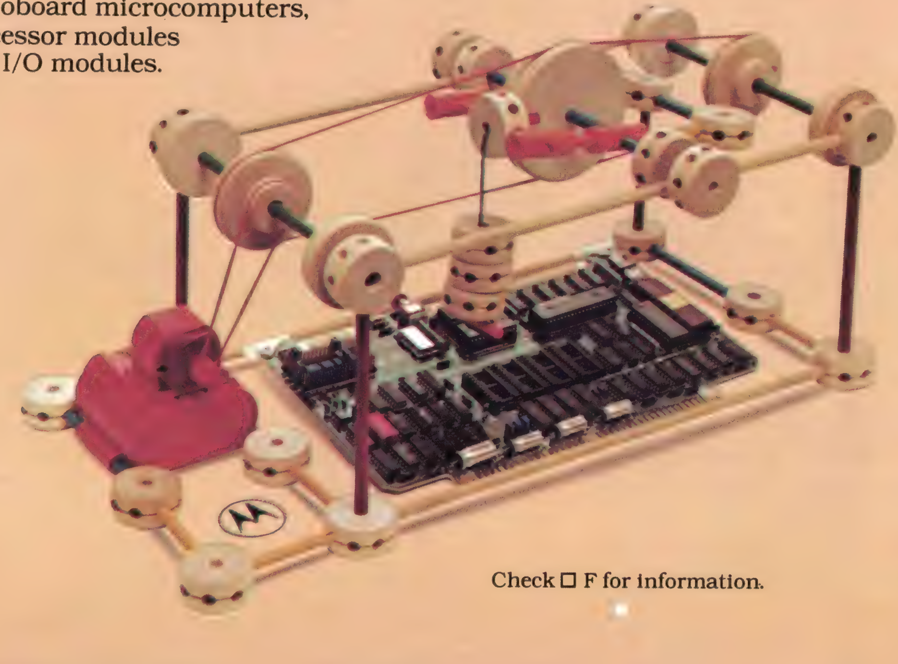
However, designing your system with Motorola's Micromodule™ family of board-level building blocks reduces your design and production time, and your effort to a minimum.

With the childlike simplicity of plugging together a single-board microcomputer or processor module with additional memory and/or input/output modules, how much easier could it be?

The basic Micromodule system-building elements are in a broad selection of M6800 family-based versatile, powerful, ready-to-run modules. Using the Micromodule system-planning worksheet if you wish, make your choices among monoboard microcomputers, processor modules and I/O modules.

Additional principal system functions needed are available, too. You'll find CPU and high-speed math processor modules, RAM, ROM and EPROM modules, serial and parallel I/O modules including IEEE-488 GPIB, high-and low-level analog I/O modules, and solid-state relay and auxiliary support modules. Add as many, or few, of these as needed for your system.

Micromodule firmware/software, documentation and EXORciser®/EXORterm™ development systems save additional time and cost. With Micromodule packaging/hardware, including card cages, power supplies, complete chassis and CRT monitor, everything you need is available from one reliable broad-line supplier . . . Motorola.



Check ☐ F for information.

Motorola's button rectifier makes UL-recognized bridges fast, easy, economical.

The technology that's produced millions of trouble-free, automotive button rectifiers *this year alone* has spun off a family of 50–400 V, 25 and 35 A bridges hard to beat for today's demanding, cost-versus-performance design standards: the MDA2500/3500 series.

The MDA2500 is a direct technology takeoff from its big brother and offers a compact, easy-to-install, 25 A bridge replacing four DO-5 packages at a fraction of their cost. An MDA2500, 50 V unit costs just $1.90. Four equivalent 1N1183 DO-5 discretes run about $5.32, not counting hardware and assembly. A 200 V, MDA2502 is only $2, far less than the $8.80 needed for a comparable DO-5 installation.

Both families surpass the UL-required, 2 kV base isolation standard, too, enhancing their reputation for durability with rugged performance. And there's no complex heat sink, hole drilling, insulator soldering or hardware necessary . . . just one mounting hole and four fast-on connectors does it.

400 A surge is standard.

Both series offer fast recovery versions for use in power supply outputs and avalanche types for severe transient problems.

Check ☐ G for information.

Discover Motorola's 64K memory world.

Find the 64K memories your systems require in the 64K world created by Motorola's advanced NMOS memory technology: leadership 16-pin single-supply 64K dynamic memory, industry-standard 64K ROM and compatible 24-pin 64K EPROM.

MOTOROLA • RAMS • ROMS • COMPATIBLE EPROMS
64K

The first compatible 24-pin 64K EPROM.

Motorola's MCM68764 is the first 64K EPROM to be directly compatible with 24-pin industry-standard ROMs and EPROMs.

It's Motorola's innovative approach, the natural solution.

The 64K EPROM drops right into existing 24-pin ROM or EPROM sockets as easily as it provides prototyping and debug in state-of-the-art systems.

Check ☐ H for information.

The industry-standard 64K ROM.

The MCM68A364/68B364 byte-oriented mask-programmable ROM is the largest in Motorola's pin-compatible ROM family with industry-standard pinouts. It is designed for use in bus-organized systems and is compatible with the M6800 family of microcomputer components.

It is a single +5 V supply device with automatic power down and low 150 mW active and 30 mW standby typical power dissipation.

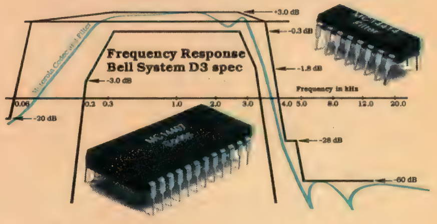
Check ☐ H for information.

MCM6664, the 64K RAM with on-chip refresh.

The MCM6664 is a +5 V-only RAM that packs high performance in a 16-pin package. It's already an industry-standard. Automatic— and self-refresh control on pin one permits reduced system parts count, reduced system noise and simplifies system refresh controller design.

Check ☐ J for information.

LSI codec and filter meet D3 system specs.



Motorola's MC14406/7/4PCM codecs and MC14414 PCM filter together meet or exceed all Bell System D3 voice frequency requirements and objectives, and are compatible with G.712CC1TT recommendations. They're available from the factory now.

Both the technologically advanced codec and filter are mass produced on our established, reliable metal-gate CMOS line, one of the most prolific and dependable CMOS manufacturing operations in the world. That means we'll be able to keep costs down and meets schedules with the quality you depend on.

The 24-pin MC14407 codec provides pin-selection of A-law or Mu-law companding with D3 digital format, and the MC14404 does the same with CC1TT digital format. The 28-pin Mu-law MC14406 offers transmit and receive LSB signalling. All three are designed for 8K samples per second, and no other codec challenges the low on-hook power drain of just 1 mW.

The MC14414 filter has both transmit and receive low-pass filters on-chip, and on-hook power use is only 1 mW.

See that your customers get what they have to have: systems that meet specs, including the sensitive idle noise spec of 23 dBrnCO. Motorola's codec-filter team is typically 17 dBrnCO.

Check ☐ K for information.

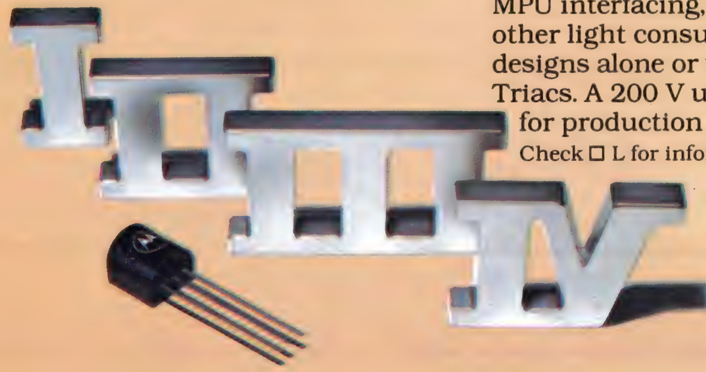
Drive from logic sink or source with sensitive-gate Triacs.

I, II, III, IV . . .

Motorola introduces a series of 0.6 to 0.8 A triacs in the popular TO-92 package designed to be driven by low-level logic in any gating mode. The MAC91A-96A family offers gate characteristics of 3, 5 and 10 mA—low enough to match input drives of MOS.

You can use them in logic-sinking current designs, quadrants II and III, or in AC applications such as solid-state relays where triggering occurs in quadrants I and III.

Or in logic-sourcing current designs, where triggering is normally in quadrants I and IV.



Or even in negative DC circuits, where the trigger signal is an alternating source and occurs in quadrants III and IV.

The family can be directly triggered by CMOS. TTL and NMOS circuits require only a small additional buffer.

The Motorola-originated TO-92 Unibloc™ package is inexpensive, utterly reliable and offers one-piece injection molding for excellent environmental and temp cycling, all diffused, glassivated junctions for max parameter uniformity and automatic insertion capability.

Use them in solid-state relays, MPU interfacing, TTL logic and other light consumer/industrial designs alone or with larger Triacs. A 200 V unit is under 30¢ for production lots.

Check ☐ L for information.

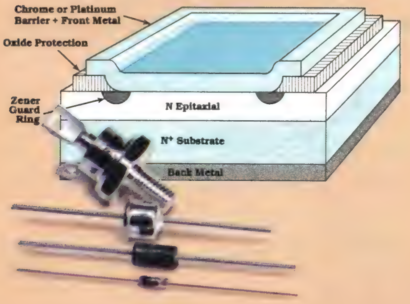
Schottky rectifier technology keeps outside world outside.

We tested 849 Motorola DO-4 and DO-5 units to stringent, MIL-STD-750 acceptance criteria, including HTRB, 1,000- and 3,000-hour operating and storage life at 150° and 200° C plus all the shake, rattle and roll we, and the MIL, could think of.

There were no failures.

Full reports with variables data are available.

Motorola Schottkys now have an extra layer of barrier metal that effectively shuts out contamination and failure.



It's an intermediate layer of interface metal between the actual, working barrier metal of chrome or platinum (depending on family) and the nickel-gold ohmic contact metal.

The technique is extensively employed in LS fabrication and has made Motorola power Schottkys more reliable than ever.

In addition, we've replaced the copper disc on each side of the die with a molybdenum one closely matching TCE of silicon to improve power stress capabilty, changed to a conventional C-bend to increase electrical contact area and instituted line tests and inspections of the complete sandwich to assure a controlled process.

Constant improvements like these in our 3–75 A Schottky rectifier line indicate Motorola's unshakable commitment to supplying the switching power supply market with the highest quality product. After all, we invented them.

Check ☐ M for information.

Microwave power lines geared up for the '80s with 2 GHz CW and 1 GHz pulse.

Motorola will sustain the kinds of quantities needed to keep avionics DME, phased-array radar and JTIDS/ TACAN production lines moving during the '80s.

In fact, we are—with a broad line of power parts at prices half those of less-committed sources.

The MRF2010/2016M units provide 1–16 W performance at 2 GHz. They're 100% tested for load mismatch at all phase angles with 10:1 VSWR. They offer gold-metallization and resistance to metal migration. Semi-automated, gold-wire bonding ensures consistent impedance from unit to unit and complete, characterization, including test circuits with corresponding data

Long live rugged, high-surge, Motorola SSRs and I/O modules!

Look inside a Motorola solid-state relay or I/O module and you'll find things like copper heat spreaders that ensure even thermal gradients, efficient device cooling and inherently higher performance at any temperature.

A Motorola P120D3 board-mounted, free-air-cooled unit, for example, furnishes 3 A at 45° C, fully one-third more than a comparable *with* a heat sink.

The 5 A and 10 A M120D05A and M240D10A furnish 100 A and 150 A surge ratings, respectively, while nearest comparables offer only 55 A and 100 A protection.

Motorola SSRs and I/O modules are 100% tested under inductive load for all key parameters: leakage, forward drop, breakdown, isolation and turn-on threshold. And, they're tested at both board level and finished unit status to attain highest degree of integrity and user confidence.

The opto couplers employed are tested to 7.5 kV peak. This unmatched ruggedness, plus sufficient board spacing, rates our units at a 4 kV isolation, exceeding European and IEC requirements as well as UL specs. And better input characteristics limit coupler current, holding it to a minimum and extending coupler, and relay, life expectancy.

Covered footprints . . . MPU-compatibility . . . advanced circuitry . . . handling of MIL-spec shake, rattle and roll . . . conformal coatings . . . base standoffs and constant line improvements provide more no-compromise yardsticks that make our products just a bit better than others.

Accept no substitutes.

Check ☐ P for information.

CMOS op amps and new PLL frequency synthesizer now in standard CMOS.

Our first standard CMOS operational amplifiers and a new PLL frequency synthesizer now further diversify the line which has grown to leadership in breadth, factory capacity and dedication to the marketplace.

Basic linear building blocks—in CMOS.

Op amps, the basic building block of linear systems, are still very new in CMOS. Now a family of low power quad comparators and internally compensated quad op amps is available in standard Motorola CMOS.

The MC14573 is a quad programmable op amp, the MC14574 is a quad programmable comparator and the MC14575 is a combination programmable dual op amp/dual comparator.

They can be used almost everywhere. Active filter, voltage reference, function generator, oscillator or A-to-D converter are just a few of their applications in systems ranging from consumer to industrial, from automotive to instrumentation. They're for both line-operated and battery-operated systems, too.

All are CMOS- and TTL-compatible, and the comparators are JEDEC B-Series compatible.

Check ☐ B for information.

CMOS PLL frequency synthesizer operates to 25 MHz.

The MC145143 is a new phase-lock loop variation on the standard CMOS MC145143/MC145112 family that uses silicon-gate technology to attain higher operating speeds.

The MC145143 contains oscillator circuitry to operate with fundamental mode crystals to 10.24 MHz, or square wave inputs to 25 MHz. The reference oscillator can be divided in steps of 16 between 32 and 8176 before interfacing with the phase detector. Three-state phase detection and on-chip lock detection are also featured.

These CMOS PLL frequency synthesizers maximize system design flexibility and help reduce the parts count of previous approaches. They are microprocessor compatible, too.

Check ☐ C for information.

Get 12-week turnaround on high-performance custom LSI.

Motorola's MACROCELL™ Array has drastically reduced the time, cost and difficulty of obtaining sub-nanosecond, high-density, custom LSI.

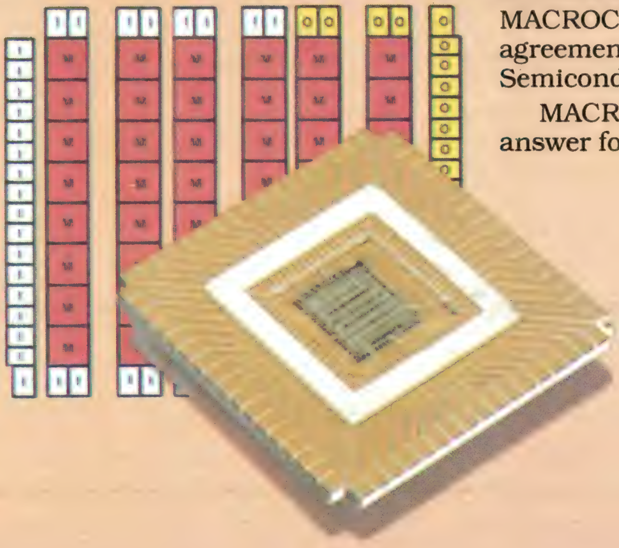
The MACROCELL Array is a MECL 10,000-compatible array of 106 cells that provide up to 1192 gate equivalents. It's easy, cost-effective and provides quick turnaround because you, the user, simply access the library of predefined LSI logic functions stored in our computer.

You select the right combination of up to 48 major cells, plus 32 versatile interface and 26 output cells. Design flexibility is enhanced by the fact that many of the major cells in the library may be half celled.

You work on your own terminal, at your own location. Using normal CAD procedures, you choose library cells and place them on the standard MACROCELL diffusion set. Customers with CALMA capability sometimes prefer to interface via CALMA tapes, and we'll operate that way if it's your choice.

Next, develop your interconnect scheme, and finally, develop your own test routines. Most of the circuit design tedium has been removed with the MACROCELL concept, because the MSI logic elements are predefined. Interconnect paths are easier to design because each major cell has 12 horizontal and 12 vertical interconnect channels.

Additional steps have been taken to make the MACROCELL design job easier for the user. One is a graphics check program to help you minimize graphics errors. Another is a logic simulation program you can use to verify your logic.



Once your design is ready, turn Motorola loose and we'll deliver prototypes in 12 weeks, max.

With circuits of this nature, power dissipation could be prohibitive, but the MACROCELL Array, even with all cells used, dissipates just 4 watts. The circuit, by the way, uses a JEDEC-standard, 68-pin leadless package.

In a recent major second-source action, Motorola announced the signing of a MACROCELL second-source agreement with National Semiconductor.

MACROCELL is clearly the answer for bipolar custom LSI.

Check ☐ D for information.

Technological leadership.

Motorola ICEMAN™ power supplies offer more of what you're looking for.

ICEMAN linear and switching power supplies offer performance and reliability that won't melt away.

Conservative design philosophy and guardbanding, hefty heat-sinking and state-of-the-art componetry make ICEMAN supplies the new standards in a long line of comparables.

The 400 W, 25 kHz pulse-width modulated family is designed for use with MPUs, small computers and NC. It offers remote turn-on/turn-off, soft-start circuitry to eliminate voltage overshoot and limit inrush current, overcurrent and overvoltage protection with automatic reset.

Total parts for the single-output unit—143, or about 25% less than the nearest comparable. You can't damage an ICEMAN turning it on and off and it's virtually blowout-proof. We've even specially-wound the transformer to cut losses.

The PSN/PSD/PST series meets not only our own high standards but is available to meet specs of those who set the industry's: UL and EMI requirements (Curve A of VDE0871/6.78).

ICEMAN linear units provide 50% to 100% more square inches of heat sink area than others. This spreads power transistor locations over a much greater area so heat is dissipated faster, more efficiently, and the supply runs cooler and more reliably.

Besides standard foldback current protection, ICEMAN PLN/PLT linears furnish the latest OVP technology using Motorola's MC3423 and the 2N6504 SCR which short the supply output and force it into current foldback.

Outstanding linear and switching supply efficiency is provided because basic ICEMAN design ensures power transistors run at 75% or less of max T_J at 100% P_{out}: 100° C for plastic transistors and 150° for hermetics. That's industry-unique.

Check ☐ S for information.

ICEMAN	TYPE	OUTPUT
PSN1801	Switcher	5 V/80 A
PSN1802	Switcher	5 V/60 A, 12 V/8 A
PSN1803	Switcher	5 V/60 A, 12 V/4 A, 12 V/4 A
PLN800-820 series	Linear	5 V Single
PLT800-841 series	Linear	5 V and 12 V, Triple

Technological leadership. In a broad line of component and system products. In volume. From Motorola. It's your assurance of

Innovative systems
through silicon.

MOTOROLA INC.

Coupon missing? Contact your Motorola sales office or authorized Motorola distributor for information or write Literature Distribution, Motorola Semiconductor Products Inc., P.O. Box 20912, Phoenix, Arizona 85036.

13086

TO: Motorola Semiconductor Products Inc., P.O. Box 29012, Phoenix, AZ 85036.

1-E D

Please send me product information on:

- ☐ A. MC68000
- ☐ B. CMOS Op Amps
- ☐ C. CMOS Frequency Synthesizer
- ☐ D. MACROCELL™ Array
- ☐ E. MJ10020/21 Switchmode Darlington
- ☐ F. Micromodules
- ☐ G. MDA2500/3500 Bridges
- ☐ H. 64K EPROM & ROM
- ☐ J. 64K RAM
- ☐ K. Telecom LSI Codec & Filter
- ☐ L. TO-92 Triac
- ☐ M. Schottky Rectifiers
- ☐ N. Microwave Power
- ☐ P. Solid-State Relays
- ☐ Q. MC3447 Octal GPIB Transceiver
- ☐ R. Memory Systems
- ☐ S. Power Supplies

☐ Please have a salesman call.

PHONE ____________________

Name ____________________

Title ____________________

Company ____________________

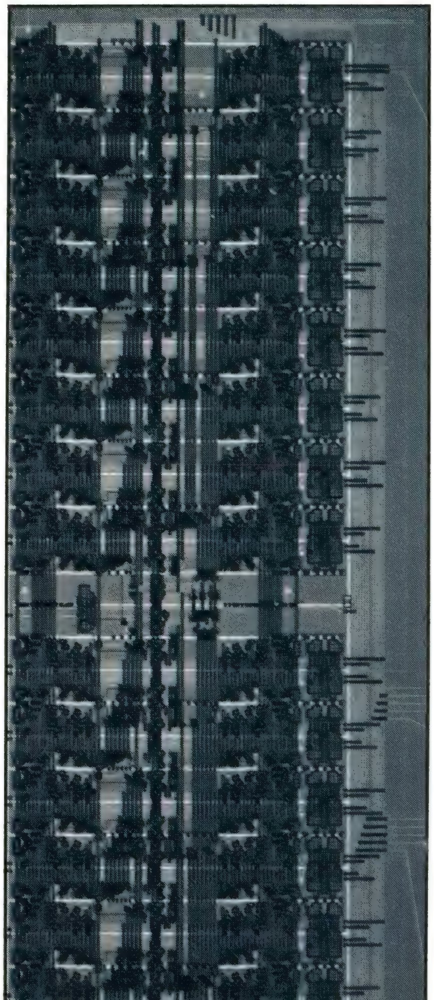
Address ____________________

New era for LSI: specialized circuits

Semiconductor technology, the driving force behind electronics for the past three decades, speeds into the 1980s; and no other conference more accurately measures its progress than the annual International Solid State Circuits Conference. This year's ISSCC brings together semiconductor technologists from around the world (more than one-third of the papers come from outside the United States), who will present the latest in digital and linear LSI devices. Even more significant, however, is the wealth of new devices aimed at telecommunications. Because of refinements in LSIs, digital and linear circuits now work together on a single chip—and in no other application must digital and linear technology be combined to the degree made necessary in telecommunications.

The coverage of telecommunications LSI includes such devices as a bidirectional crosspoint switching matrix that handles up to 500 V, subscriber-loop interface circuits, adaptive echo cancellers and LSI filters based on switched capacitors, bucket-brigade devices, and gyrators.

One VLSI chip from researchers at Bell Labs contains 45,000 transistors for digital signal processing. Both the architecture and the instruction set of this special-purpose microprocessor sustain its rapid processing and arithmetic accuracy, as required in applications such as filtering, modulation and demodulation.



Density and speed arrive, both at once, in 64-k and 128-k UV EPROMs and in dynamic and static RAMs. Intel's UV-EPROM accesses in less than 200 ns, and shows a 75% reduction in chip area; a 128-k UV EPROM (from Texas Instruments) comes on a chip 41,500 sq mils in area; and the dynamic RAMs boast capacities as great as 512 kbits. The relatively small chip sizes and super densities are the payoff from new processing techniques and new circuit layouts. (The photo, left, shows a gate-matrix chip, developed at Bell Laboratories, Murray Hill, NJ, with densely packed CMOS devices.)

With no sacrifices in their own accuracy, speed and capacity, analog-to-digital converters offer more conveniences—like front-end sampling and memory—all on one chip. Where speed, rather than convenience, is the primary consideration, Plessey has a monolithic 8-bit DAC with a full-scale settling time of less than 5 ns. Speed is also the latest feature of 12-bit converters, hitherto chosen only for their greater resolution.

Among special-purpose circuits are a CCD-based comb filter for color television, a ROM-controlled radio tuner, an I^{2}L servo for video recording, and several CCD image sensors for color TV cameras.

This ISSCC Special Report covers four application areas for LSI:

Digital 43
Linear 49
Telecommunications 57
Special-purpose 63

Superior X-Y value.

Now, a high performance X-Y recorder without a high price. Introducing the Gould 3054, the X-Y recorder with value superior to any other analog recorder in its price or performance ranges. It's the first of an all-new series of high performance X-Y recorders designed to handle a broad range of applications in industrial, scientific, and biophysical measurement. For a much lower cost than you'd expect, the new Gould 3054 gives you the fast, sensitive response needed to provide precise, permanent records of the relationships between two analog variables.

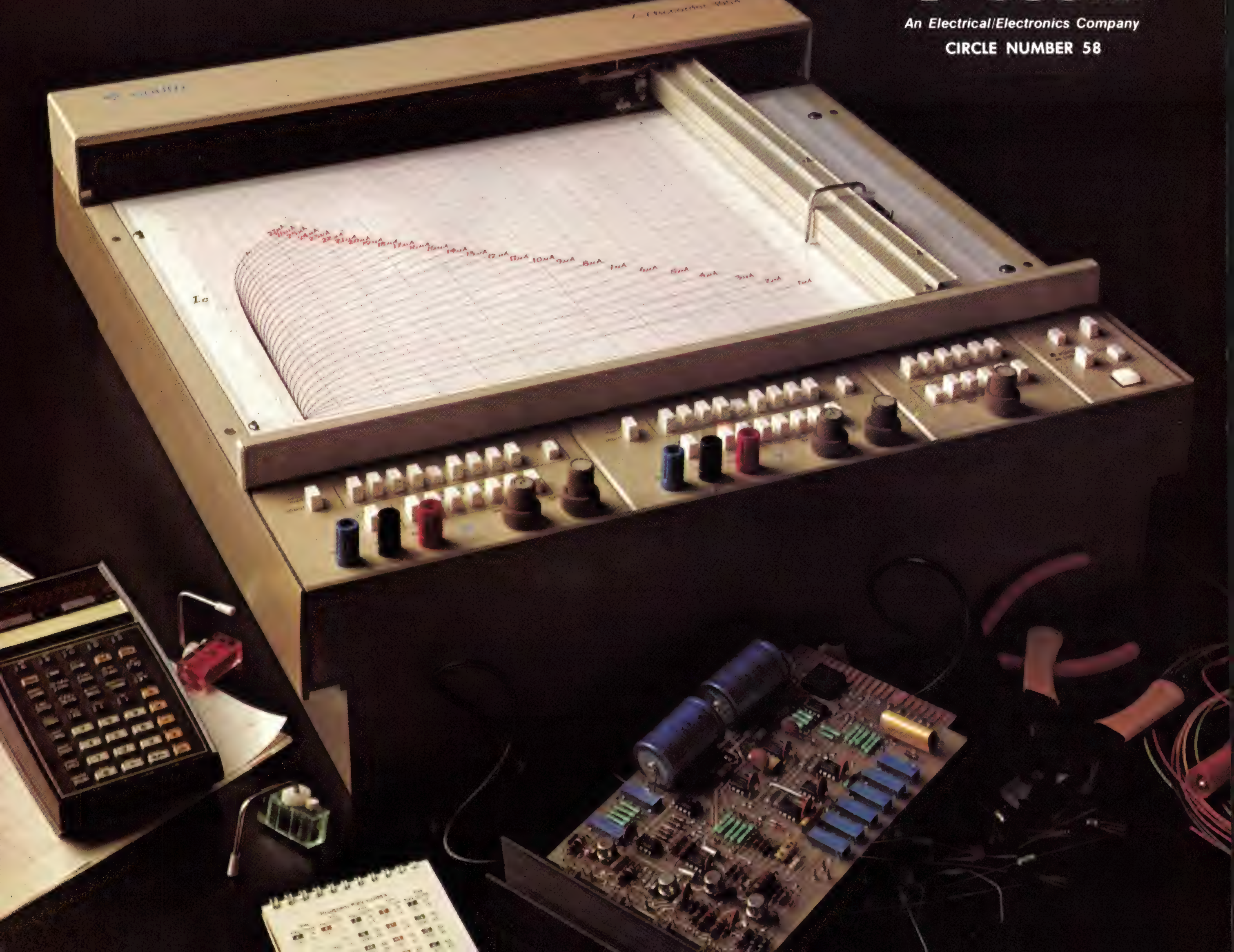
The new Gould 3054 offers performance and features normally found only in much more expensive, less flexible instruments. The high speed drive system provides for high system fidelity with a minimum slewing speed of 85 cm/sec and accelerations of 7700 cm/sec^2 in the Y-axis and 5100 cm/sec^2 in the X-axis. Advanced X- and Y-axis preamps with sensitivities down to 200μ V/cm ensure recorder flexibility.

In use, a simple, disposable fiber-tip pen system provides a high quality fine line trace. Improved electronics servo protection ensures instrument reliability. Also included are calibrated zero offset, a switchable low pass filter, and switchable input polarity reversal. Plus, an optional time base is available.

Find out more today about what makes the new Gould 3054 superior to anything in its price or performance ranges by writing Gould Inc., Instruments Division, 3631 Perkins Avenue, Cleveland, OH 44114.

For brochure call toll-free: 800-331-1000.
In Oklahoma, call collect: 918-664-8300.

GOULD
An Electrical/Electronics Company
CIRCLE NUMBER 58



ISSCC

Super chips spur super memory designs

Changes in layout and processing techniques are sparking the emergence of superdense, superfast UV EPROMs and static and dynamic RAMs. The reductions in chip area, power dissipation and access times, as discussed at the ISSCC, produce 64-k and 128-k UV EPROMs that access in 200 ns or less; dynamic RAMs with capacities of 512 kbytes; and 16-k static RAMs that fit on a chip less than 45,000 sq mils in area.

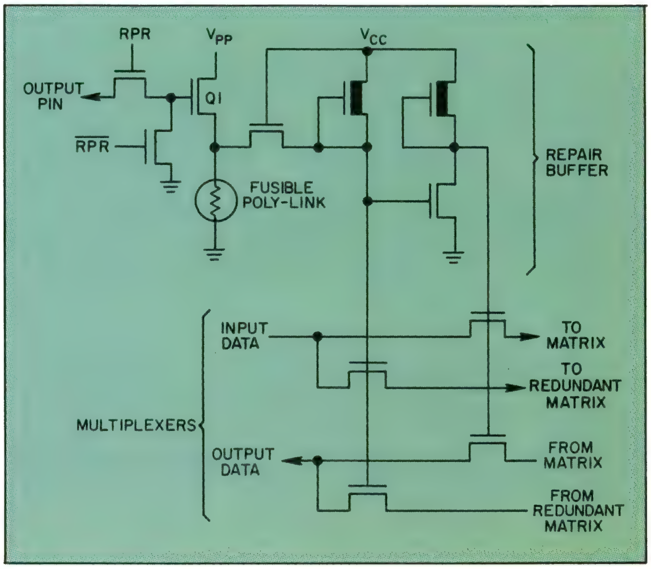
From a team of six researchers at Intel (Santa Clara, CA) comes a UV EPROM with a cell size of just 0.25 sq mils. This cell size translates to a chip with an area of 32,399 sq mils—about 25% smaller than other 64-kbit devices. To get the density, Intel combined a two-layer poly self-aligned memory cell with a scale NMOS periphery. With the high density comes fast speed—access time for the device is typically less than 200 ns.

Circuit improvements contribute to the performance of the EPROM; namely, a differential sensing scheme and the use of transfer gates within the array's X-decoder. The differential sensing, in conjunction with a special reference circuit, improves the sensing margins. The transfer gates between X-decoder and X-select sections localize the high voltage during programming.

As another performance bonus, a lower programming voltage—20 V instead of 25—is attained by using arsenic junctions to overcome the lower breakdown voltages and by increased coupling through thinner oxide layers. The first oxide layer is scaled down in thickness to approximately 700 Å and the second to approximately 800 Å. Programming also speeds up, becoming about twice as fast as in earlier devices.

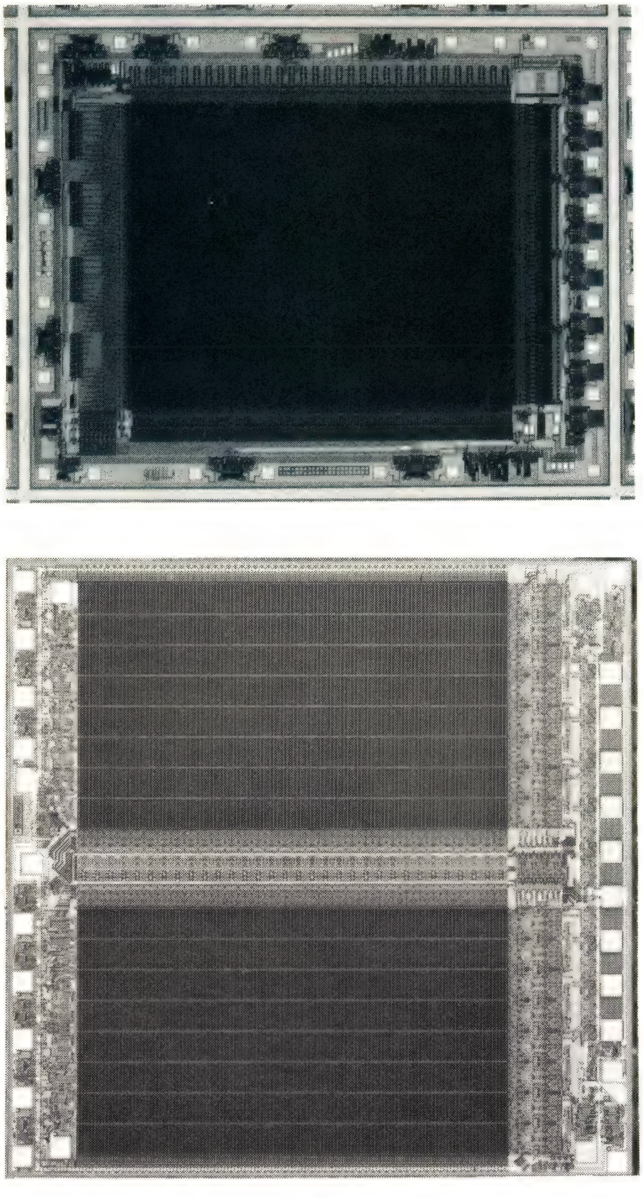
With a double-poly HMOS process, Motorola (Austin, TX) produces a 64-kbit EPROM on a 42,500-sq-mil chip. According to Stephen Smith and John Yeargain, a 4-μm line width keeps the size of the memory cell to 167 μm^2. The cell consists of single floating gate devices that share bit-sense and virtual-ground contacts.

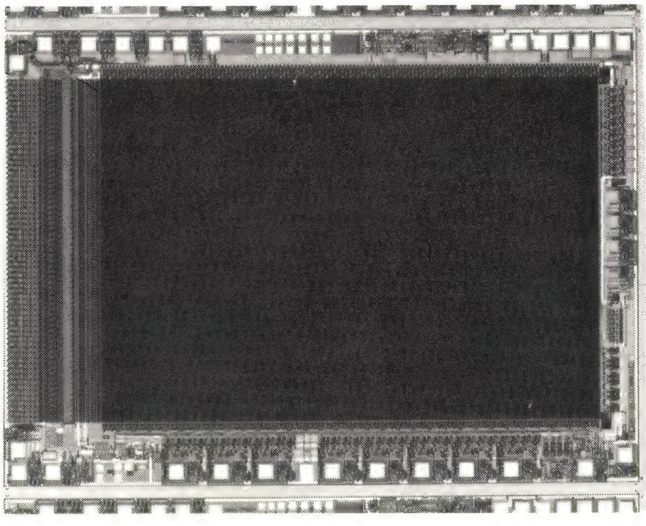
Dissipating just 100 mW in its active state, the UV EPROM offers a typical access time of 165 ns and requires a programming voltage of just 20 V, instead of 25 V. Programming time is typically less than 5



By combining polysilicon fuses with EPROM technology, Mostek includes redundant cells in its version of a 64-k EPROM. The fuse controls a multiplexer that determines whether data go into the main memory area or into the redundant cell.

Dave Bursky
Semiconductors Editor





EPROMs are extensively covered at ISSCC. Shown are Motorola's 64-kbit device (top), which operates with 100 mW and accesses in 165 ns. Intel's 64-k device (center) also accesses in less than 200 ns, while Texas Instruments' 128-kbit device (bottom) accesses in about the same time interval.

ms/8-bit word, under a programming technique that uses a single pulse per word.

UV EPROM contains redundant circuits

The cell structure of Mostek's (Carrollton, TX) 64-kbit UV EPROM has evolved from their 64-kbit ROM introduced at last year's ISSCC. It also incorporates the self-aligning floating-gate structure of the 2716 EPROM. The result, described by Senior Memory Design Engineer Vernon McKenny, is a 14 × 14-μm cell. To improve yield and reduce the cost of the chip, Mostek built in redundant circuitry for the memory matrix, column decoder, column select, sense amps and data-in buffers.

Up to 25% of the memory can be repaired—however, the chip area increases about 20% (to more than 50,000 sq mils) to implement the redundancy. The increase in good active area is actually less than 2%.

During wafer testing, polysilicon fuses are blown to replace defective circuitry. When an error is detected at an output, the chip-enable input must be brought to 25 V. This input changes internal voltages and activates the gate of a fuse-control transistor. Then a 25-V level is placed on the output pin that had registered a bad output. With the transistor activated, the fuse in its drain circuit is blown. When the fuse blows, it changes the state of the signals that control a memory-matrix multiplexer and routes the data flow through the redundant circuit section.

A team of researchers from Texas Instruments (Houston, TX) unveils the company's new X-series of scaled MOS devices—a superfast 32-kbit EPROM that accesses in just 100 ns, and a superdense 128-kbit unit that accesses in about 200 ns.

Performance in the FAMOS cells is improved by combining a modified channel-doping process with scaling. The reduced channel-doping concentration results in higher gains during saturation; under 3.5-μm design rules, the 128-kbit device is fabricated on a chip with an area of just 41,500 sq mils—about the same size as Motorola's 64-kbit device.

The 128-kbit unit uses an edge-enable power-switching scheme to keep power to just 15 mW in the standby mode and 100 mW in the active mode. Yet, access time is not sacrificed—the jumbo unit accesses with the best, at just 200 ns typical.

TI tightened its design rules for the 32-kbit unit. It dropped down to 3 μm and developed a test chip with an area of 16,500 sq mils. The small size and cell improvements yield an access time of just 100 ns and reduce programming voltage to 21 V. The chip does have one penalty, though—power dissipation goes up to 400 mW when the chip operates at its maximum speed.

Additional papers by Intel at ISSCC cover two more technologies—bipolar PROM and floating polysilicon gate NMOS EEPROMs. Using a standard diffused-Schottky bipolar process, Robert Wallace, Arthur Learn and Kenneth Schuette of Intel developed

Memory uses grow with density

Designers are taking advantage of the growing availability and density of memory to write high-level languages and powerful operating systems. And Ted Hoff, Jr., an Intel Fellow, knows why. "With the cost of semiconductor memory coming down, designers and programmers can afford to be extravagant with its use to make their jobs easier," he says.

Continuing improvements in density will push the device capacity well past the currently being sampled 64-kbit level. But to get to the next generation or density level, Hoff warns, scaling will have to do more than just reduce device sizes. Voltage levels will also have to come down. So while it's theoretically possible to scale the devices by another factor of 10 beyond today's limits and to use device thresholds of 0.2 to 0.3 V, this will require that the supply voltage be scaled, also by almost a factor of 10. If it happens, a 0.5 to 2-V operating supply might just become a reality towards the end of this decade.

This much scaling could reduce the signal-to-noise ratio by 30 dB, but there is enough of an operating margin to protect the accuracy of stored digital information. Nevertheless, there are limiting factors for scaling, according to Hoff—notably, the accuracy of the lithography equipment and the resolution of the resist and other processing materials.

What's more, as the power of many digital systems grows, their ability to fully exploit all the available memory starts to lag—notes Hoff, partly, because of the difficulty of generating the necessary software, and partly because of the bus-traffic limitations of the interconnect hardware. Other limiting factors include the shortage of in-house system designers for the semiconductor manufacturer and a shortage of knowledge on the part of the system designer of what the semiconductor technology can do.

The gaps are slowly being closed in these areas, Hoff notes, citing IC vendors adding more system architects and system houses adding their own captive design and fabrication capability. At the same time, new system functions or capabilities are not always designed with today's capabilities in mind. In many cases, companies will work hand-in-hand with semiconductor manufacturers eventually to define and implement LSI system or subsystem functions, even though it may be several years before the actual LSI chips can be fabricated. This way systems on a chip, including smart RAMs and other memory products, will readily be implemented.

a PROM that access in 35-ns and has a storage capacity of 16 kbits (2 k × 8). The PROM takes advantage of positive-resist projection photolithography, polysilicon fuses and two-level metallization. It occupies an area of 19,600 sq mils and dissipates 600 mW.

The other 16-k device (described by five Intel researchers) is an electrically erasable 2-k × 8 nonvolatile memory that uses extremely thin oxide layers (just 200 Å) in conjunction with a floating polysilicon gate. Electrons are forced to tunnel through the oxide to or away from the floating gate, which holds the bit data. The floating-gate tunnel oxide (FLOTOX) device handles program and erase operations by Fowler-Nordheim tunneling of electrons through the oxide, using voltages of less than 25 V. Because the voltage is kept low during read operations, the cell retains a charge for more than ten years.

With a cell area of 0.85 sq mil, the FLOTOX cell uses a select transistor and a memory transistor. The memory is cleared by programming every device in a row—a row is selected and the program line is raised to the V_{PP} level of 20 V, which attracts electrons to the floating gate. To write, the cell erases selected bits within a word—a row is chosen, the program line is held at 0 V and the selected columns go to the V_{PP} level.

Access times for the EEPROM are less than 200 ns, so no wait states are needed when the device is used with the newer, faster microprocessors. The device requires a 5-V supply during normal read operation. It has a write time of just 10 ms/word and a clear time of either 10 ms/word or 10 ms for the entire chip. Data can be written into the memory more than 100,000 times before threshold degradation occurs. Power dissipation for the EEPROM is also modest—just 500 mW during access, 100 mW in standby and 0 W when it is turned off.

Researchers at NTT Musashino Electrical Communication Laboratories in Tokyo, Japan, are using a full 3-in. wafer for a mask-programmable ROM. The ROM generates Chinese ideograph characters, delivering a 16 × 18-bit pattern for each character. The memory cell in the ROM has a multi-gate structure similar to that of CCDs. Referred to as a MUGROM array, the circuit has a defect-tolerant design with a redundant block configuration that minimizes yield losses resulting from open or short-circuit defects.

RAMs also reach the 64-kbit level

Static and dynamic memory components are also benefiting from gains in density and from new design concepts. Three papers at ISSCC deal with 64-kbit dynamic memories. IBM has an 8-k × 8 bipolar dynamic device, and both Hitachi (Tokyo, Japan) and Texas Instruments have NMOS 64-k × 1 RAMs. The three companies also give details on 16-kbit devices—two CMOS 2-k × 8 units by Hitachi and Toshiba, and a 16-k × 1 bipolar unit by IBM. All the chips are well under 50,000 sq mils in area.

IBM brought researchers together from three facilities—Essex Junction, VT, Yorktown Heights, NY, and Essones, France—to develop a bipolar analog to the single-FET-per-cell NMOS dynamic RAM. The 1/N fractional device is an experimental 64-k (8-k × 8) bipolar dynamic RAM on 46,500-sq-mil chip. Its performance equals that of a bipolar—an access time of 50 ns (100-ns cycle time)—and its density is that of a MOS—a 315 μm^2 cell, using 2.5-μm lithography.

A basic 1/N device is derived by supplying N emitters for each base contact; research by IBM scientists has shown that, for a reasonable density/performance combination, N should equal 8. Basic cell operation depends heavily on the parasitic emitter/base capacitance and on the cell structure, which arranges the storage capacitor and switching device vertically.

From scaled NMOS, both Hitachi's and TI's research teams have developed 5-V only 64-k RAMs, which access in 120 ns and dissipate less than 200 mW. Hitachi's 64-k RAM uses a substrate bias generator and has a chip area close to 40,000 sq mils. TI has eliminated the bias generator and kept the chip area to less than 35,000 sq mils.

TI's design accepts dc input levels from −1 to +7 V and even handles ac transients beyond these limits. The substrate ground serves as both the V_{SS} supply and the substrate bias. An interlocked clock scheme maximizes process and voltage margins by eliminating internal race conditions. The grounded substrate reduces the noise level to improve sensing, and increases the differential signal that is applied to sense amplifiers by increasing the capacitance of a stored zero level.

Mixed structures deliver top performance

New combinations of device structures come from Sigfried Wiedmann, Klaus Heuber and Wilfried Klein at IBM in Boeblingen, West Germany. Their 16-k × 1 static RAM combines merged transistor logic (MTL) with integrated injection logic (I^2L). Although static in operation, the RAM has different access and cycle times—45-ns access and 100-ns cycle.

The chip is fabricated from 2.5-μm minimum geometries; it requires an area of less than 27,000 sq mils. Designed with on-chip voltage regulators, the memory circuit operates with a single power supply, from 2.8 to 5.5 V. Power dissipation is down—just 225 mW when the chip is continuously selected and operates with a 3-V supply and 100-ns cycle time. The memory chip can handle a separate stand-by supply, to retain data for quasi-nonvolatile applications, with a power drain of just 100 μW/chip.

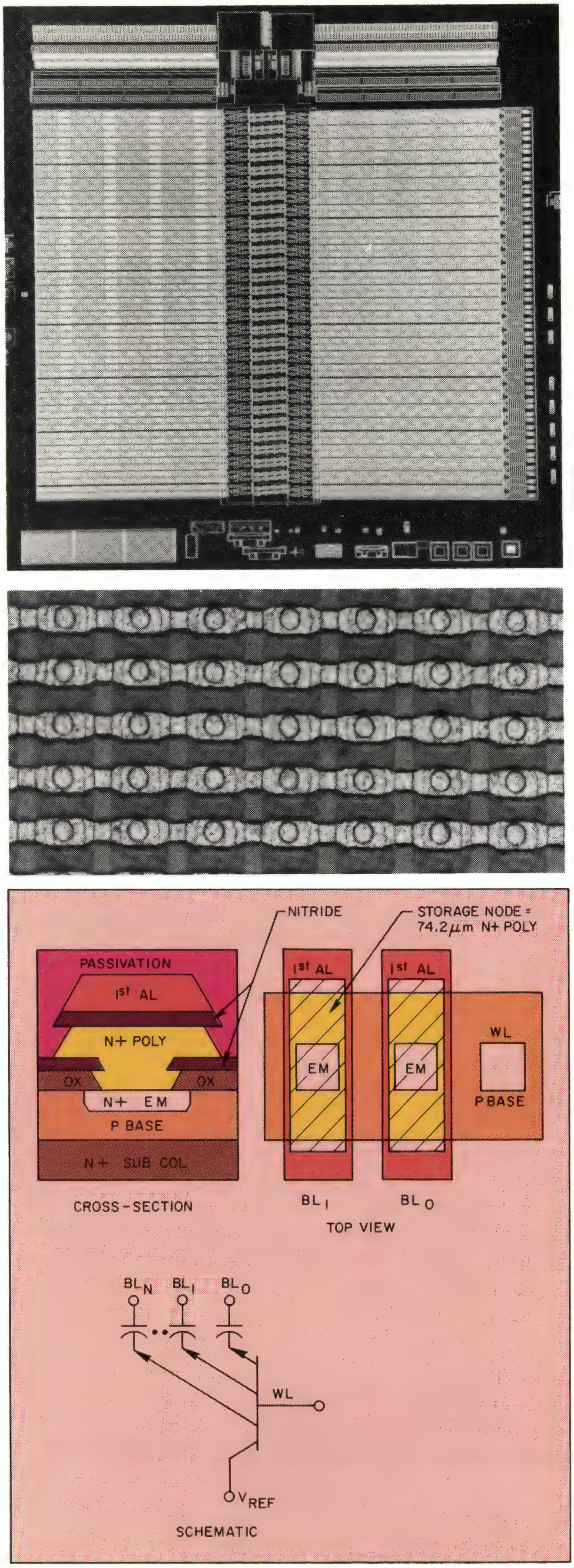
Because of advances in CMOS technology, 16-k static RAMs are being fabricated on chips with areas of less than 45,000 sq mils. Researchers at Toshiba have come up with a new cell design that, combined with scaling and dry etch processing, permits a CMOS RAM to offer a typical access time of 95 ns with an active power dissipation of 200 mW and a stand-by power of less than 1 μW.

Density was achieved partly with scaling and advanced processing techniques, which result in a gate

Memory papers at ISSCC

Company	Organization	Type	Technology	Access/cycle time (ns)	Power diss (act/stdby)	Approximate chip area (mils^2)
RAMs						
IBM	8 k × 8	Dynamic	Bipolar	50/100	500 mW/NA	46,515
TI	64 k × 1	Dynamic	NMOS	100/250	200 mW/NA	34,000
Hitachi	64 k × 1	Dynamic	NMOS	120/300	170 mW/NA	40,003
IBM	16 k × 1	Static	Bipolar	45/100	300 mW @ 3 V	26,979
Toshiba	2 k × 8	Static	CMOS	95	200 mW/1 μW	45,275
Hitachi	2 k × 8	Static	CMOS	74	200 mW/25 μW	NA
Mostek	4 k × 1	Static	NMOS	55	900 mW/150 mW/500 μW	14,000
	1 k × 4	Static	NMOS	70	625 mW/150 mW/500 μW	15,000
	2 k × 8	Static	NMOS	75	625 mW/150 mW/500 μW	35,000
NEC-Toshiba	256 k × 1	Dynamic	NMOS	160/350	225 mW/25 mW	64,500
NTT Musashino	256 k × 1	Dynamic	NMOS	100/200	230 mW/15 mW	53,350
Japan Coop Labs	256 k × 2	Dynamic	NMOS	170	NA	70,700
	256 k × 4	Dynamic	NMOS	170	NA	135,515
UV EPROMs, PROMS, EEPROMs, ROMs						
Intel	8 k × 8	UV EPROM	NMOS	200	500 mW/50 mW	33,000
Mostek	8 k × 8	UV EPROM	NMOS	250	200 mW/75 mW	57,000
Motorola	8 k × 8	UV EPROM	NMOS	165	100 mW/NA	42,500
TI	4 k × 8	UV EPROM	NMOS-X	100	400 mW/NA	16,500
	16 k × 8	UV EPROM	NMOS-X	200	100 mW/15 mW	41,500
Intel	2 k × 8	Fuse PROM	Bipolar	35	600 mW	19,600
	2 k × 8	EEPROM	NMOS*	200	500 mW/100 mW	20,000
NTT Musashino	4 Mbit	ROM	NMOS	7 μs	2 W	3-in. wafer
Matsushita	8 k × 8	Static	NMOS	80/80	300 mW/75 mW	48,950

NA = not available. All units operate at 5 V, unless otherwise noted.
*Floating polysilicon gate.
†Battery backup; super-low-current mode.



The I/N fractional device is a bipolar equivalent to the single FET-per-bit dynamic RAM cell. Developed by IBM, it permits the fabrication of a 64-kbit bipolar RAM on a chip with an area of less than 47,000 sq mils (top).

oxide thickness of 700 Å and a channel length of 2.4 μm. This yields a memory cell of 33 × 34 μm and puts 103,000 transistors on a single 199 × 227-mil chip. To keep the power dissipation low, researchers at Toshiba use a six-transistor cell rather than polysilicon-load devices and a four-transistor cell.

The device is organized as a 2-k × 8-bit RAM. All I/O levels are TTL compatible, and the chip operates from a single 5-V supply. The device is in a 24-pin package and is also pin-compatible with standard EPROMs, such as the 2716, thus providing flexibility in printed-circuit board design.

Hitachi's own high-density CMOS process (HCMOS) enabled researchers at its Central Research Laboratory/Musashi Works, in Tokyo to develop 2-k × 8 static RAMs that are faster than Toshiba's, with an access time of 74 ns typically. Hitachi's and Toshiba's devices use approximately the same operating power, about 200 mW. However, Toshiba's RAM needs a standby power about 25 times as great, at 25 μW. Hitachi's RAMs use JFET-powered static RAM cells.

Initial design efforts by several Japanese companies have produced various super RAMs: NEC-Toshiba Information Systems has a 256-kbit dynamic unit with 160-ns access times. A unit of similar capacity, using molybdenum/polysilicon technology, with a 100-ns access time, comes from NTT Musashino Communication Laboratory. Employing tantalum oxide as an insulator, Japan's Cooperative Laboratory has developed a stacked-capacitor cell for dynamic RAMs; their latest design reaches 512 kbits. Matsushita has prototypes of a 64-kbit static RAM, with an access time of 80 ns and an active power consumption of 300 mW.

Static RAMs ease battery back up

Designers at Mostek have created a new circuit design within their static RAMs that permits the RAMS to retain data at ultra low-power levels. Already implemented in 4-k × 1, 1-k × 4 and 2-k × 8 RAM organizations. Mostek's solution to battery backup eliminates the need for a second supply voltage connection. To use the backup, the user must supply a 5-V level to the writer-enable pin, and the system power supply can then be dropped to V_{SS} (ground).

Basically, Mostek has included a special circuit within the V_{CC} line to sense when the supply voltage drops 1-V below the voltage on $\overline{\text{WE}}$. At that time, the voltage level on the $\overline{\text{WE}}$ pin takes over in supplying the memory array. Then, peripheral circuits on the memory chip that are normally powered by the supply voltage dissipate no power.

Current drawn through the $\overline{\text{WE}}$ pin in the backup mode is just 3 μA. During normal operations, however, all circuits, including the memory array, are powered by the voltage at the supply pin and the loading of $\overline{\text{WE}}$ by internal circuitry is negligible. ▪▪

ISSCC Report continues on p. 49

DDC has developed the world's fastest hybrid 12 bit and 8 bit data acquisition components. The 12 bit has a throughput rate of 450 kHz and the 8 bit has a throughput of 900 kHz. Each consists of two compatible stand-alone 24 pin DDIP modules: an A/D converter and a track/hold or sample/hold amplifier.

The 12 bit ADH-8516 Analog-To-Digital Converter has a conversion time of 1.8μs and 0.012% linearity. It is the smallest Hi-Rel A/D available that also includes 3-State outputs for microcomputer interfacing. With the matching ADH-050 Video Track and Hold Amplifier a super-fast acquisition time of 120ns is achieved. Aperture time uncertainty is a low 500ps. Buffering and pin programming allow many differential and single-ended input options.

The 8 bit data acquisition components include the ADH-8512 A/D Converter which features a 950ns conversion time. The matching SH-8518 Sample and Hold Amplifier has a 25ns acquisition time and a 60ps aperture uncertainty.

Both data acquisition component sets are well suited for military, aerospace and telecommunication applications. All DDC hybrids are processed to MIL-STD-883 requirements to perform under the most extreme environments. DDC also designs custom card mounted multiplexed data acquisition systems. To find out more, call or write Department C-1 today.

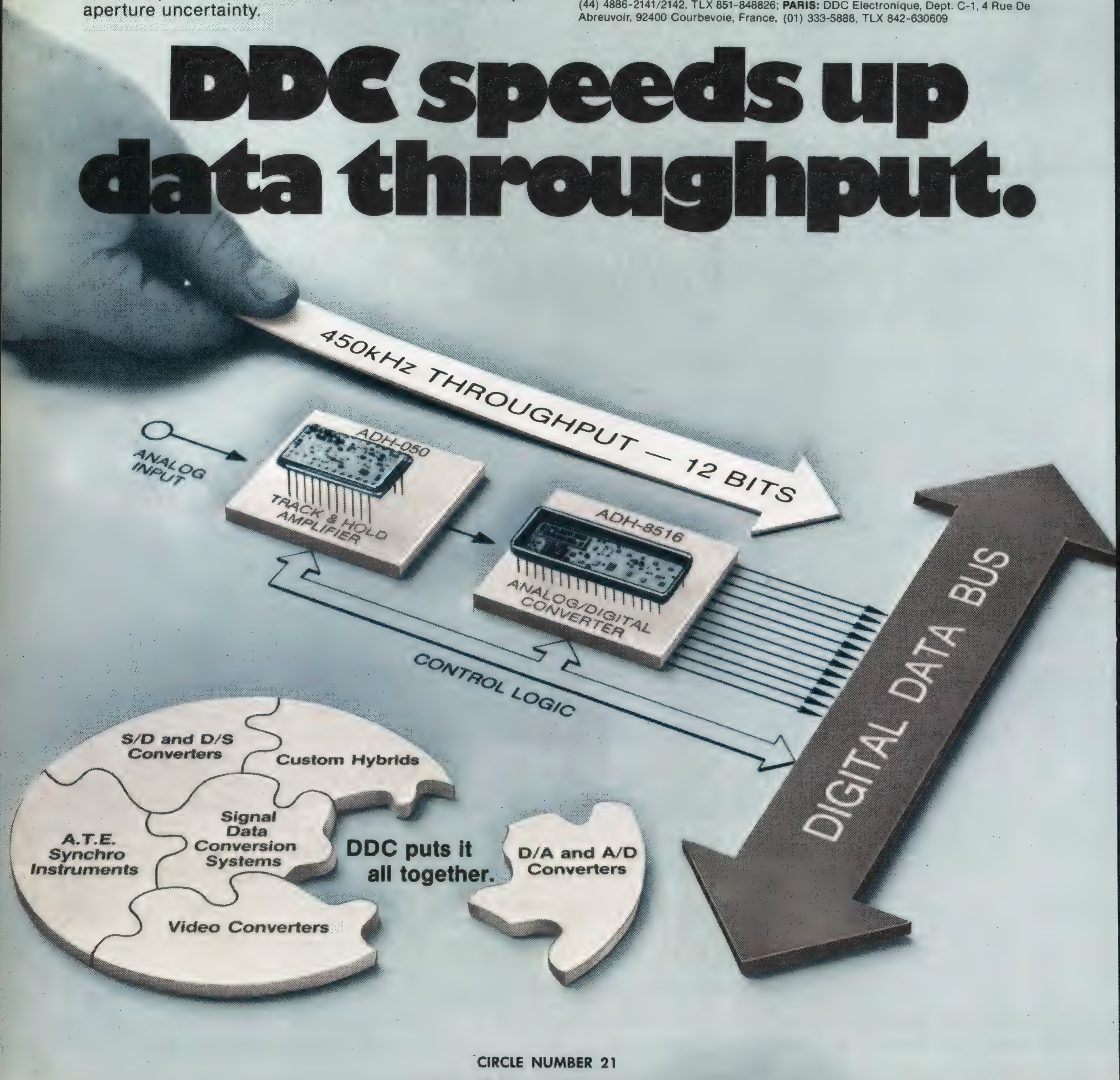
DDC™

ILC DATA DEVICE CORPORATION

Dept. C-1, 105 Wilbur Place, Bohemia, New York 11716
516 • 567 • 5600, TWX: 510 • 228 • 7324

LOS ANGELES: ILC Data Device Corporation, Dept. C-1, 7337 Greenbush Avenue, No. Hollywood, CA 91605 (213) 982-6454, TWX 910-499-2674; **LONDON:** DDC United Kingdom Ltd., Dept. C-1, 128 High Street, Hungerford, Berkshire RG17 ODL, England (44) 4886-2141/2142, TLX 851-848826; **PARIS:** DDC Electronique, Dept. C-1, 4 Rue De Abreuvoir, 92400 Courbevoie, France, (01) 333-5888, TLX 842-630609

DDC speeds up data throughput.



DDC puts it all together.

CIRCLE NUMBER 21

Linear LSI packs in user conveniences

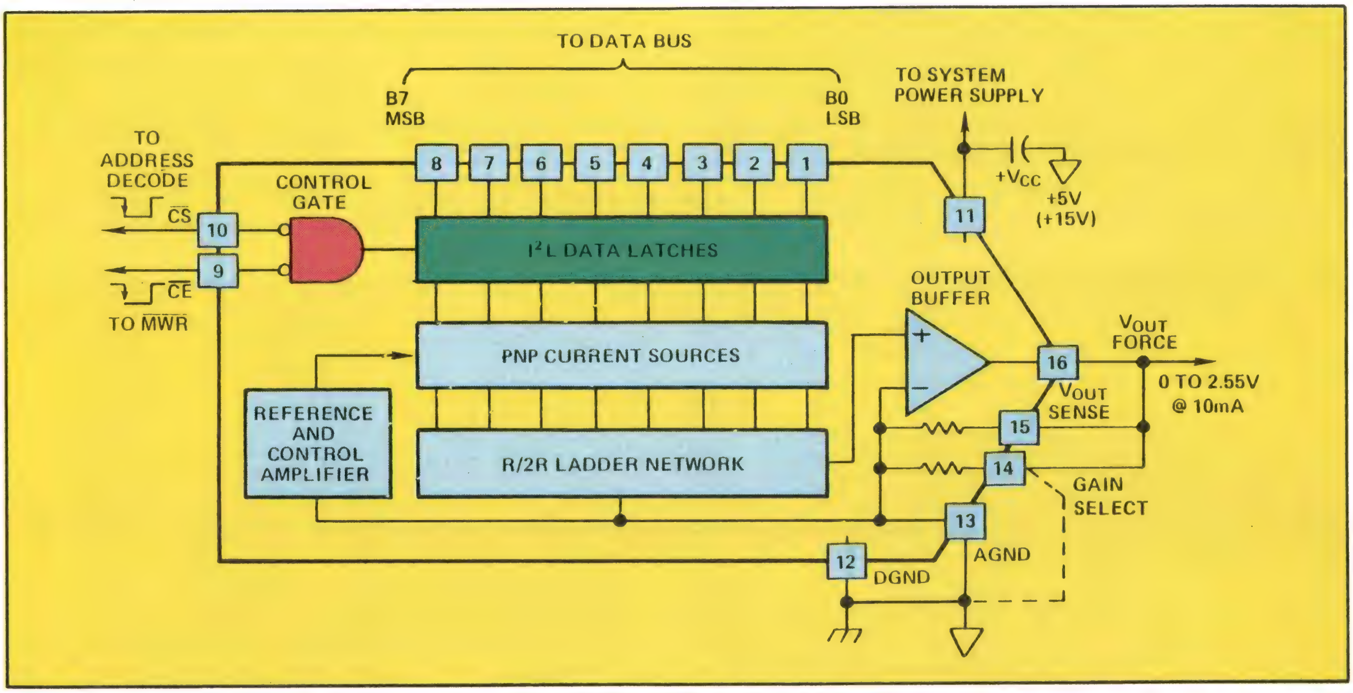
The conveniences of front-end sampling and memory on the same chip—and greater accuracy, speed, bit capacities and resolution—explain why analog and digital converters are moving to center stage at ISSCC. The a/d and d/a converters also interface readily with the most sophisticated memory and microprocessor circuitry.

The developments in a/d and d/a conversion may well eclipse those in operational amplifier circuits. Although some new devices mark advances in the specifications of op amps, most new features are under the control of the chip designer.

Stephan Ohr
Components Editor

Plug-in and go

By now 8-bit converters are becoming increasingly common for single-chip devices. If any contest exists among IC manufacturers, it is primarily in expanding the convenience, speed and accuracy of devices for a given resolution. Although 12 and 16-bit converters provide greater resolution, the small “road-



An 8-bit DAC from Analog Devices features on-chip reference and control amp, output buffers and pin-programmable gain. It runs on a single supply voltage.

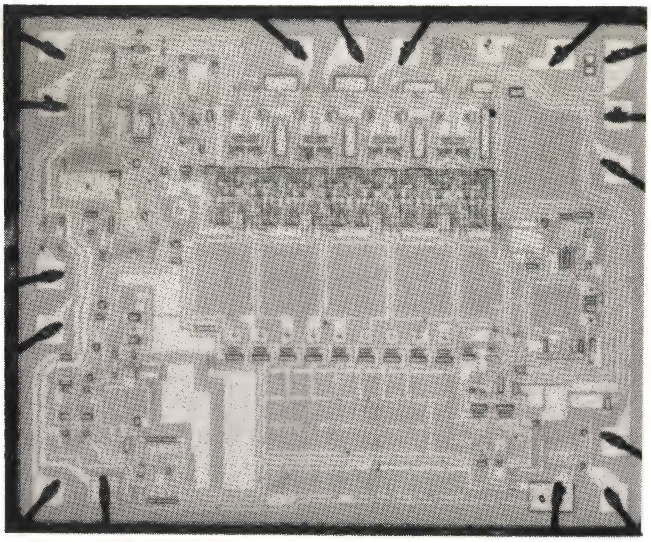
With specialized processing, I²L data latches and ECL control gates, available on the same chip, help shrink latch pulse width and data hold time.

runner devices" are faster and will offer easy-to-use, plug-in interfaces to microprocessor elements.

Exemplifying the conveniences on 8-bit converters, the 558 DAC from Analog Devices (Wilmington, MA) features an on-chip calibrated output from a single power supply voltage. According to Bruce E. Amazeen, Peter R. Holloway and Douglas A. Mercer, the 8-bit 558 uses a dense I^{2}L-compatible linear-bipolar process in the data latches, combined with an ECL control gate, to minimize the width of latch pulses and the duration of data holds. The R/2R ladder scales each bit for an output of 0 to 400 mV. The DAC's noninverting output buffer amplifier has pin-programmable gains from 6.4 (2.56-V range) to 24.9 (10-V range).

The monolithic device (Fig. 1) has a typical gain-bandwidth product of 25 MHz and consumes a small 10mW from a +5-V supply (150 mW from +15 V). The output settling time for a $\pm 1/2$-LSB error is less than 1 μs in the 2.56-V range, and 2.5 μs in the 10-V range, though the typical full-scale error for the device is 1/4 LSB.

Though Analog's 558 offers a choice of single-supply voltages and conditioned voltage output, the real show-stopper at ISSCC, in terms of convenience, is Analog's 8-channel data acquisition IC with on-board memory. Presented by D. Philip Burton, the 8-bit CMOS device features a dual-port memory, with ready interface to other microprocessor devices.



I^{2}L data latches, an ECL control gate and many conveniences combine on Analog Devices' 8-bit DAC.

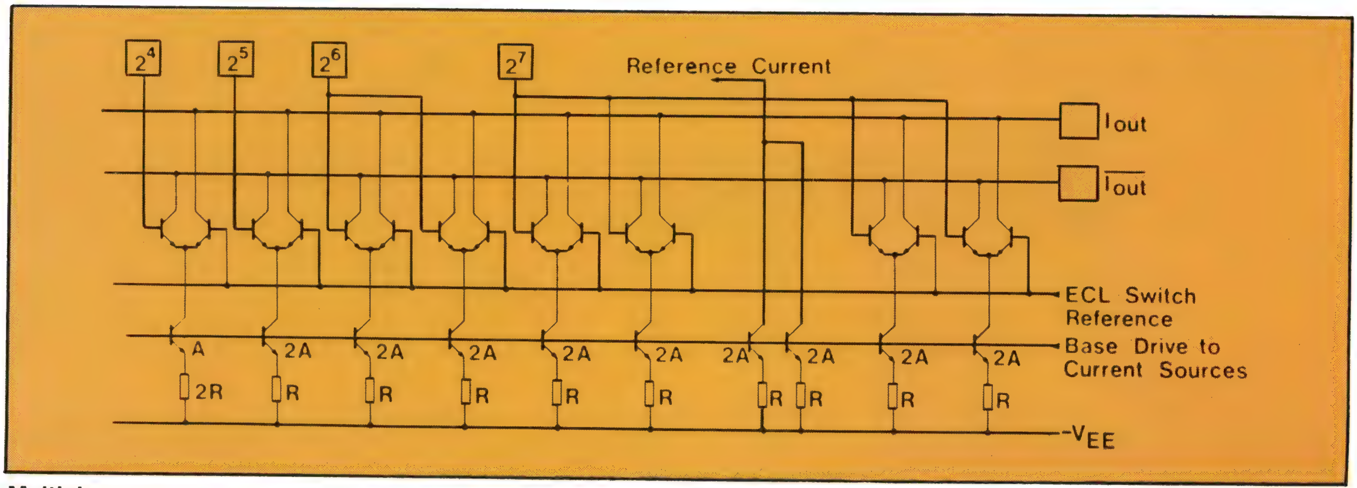
Other conveniences on the way include an autozeroing sample-and-hold IC and a trimmed 5-V temperature-regulated reference for 12-bit a/d converters, both from Harris Semiconductor (Melbourne, FL); an 8-bit DAC with programmable output ranges from researchers at Catholic University/Leuven (Heverlee, Belgium); and a time-interleaved array technique from researchers at the University of California (Berkeley, CA).

Getting up to speed

In certain application areas, speed, not convenience, is the primary consideration for a/d conversion. Video transmission systems, for example, with analog frequencies between 4 and 5 MHz, require faster conversion than most other data acquisition systems. According to P.H. Saul, P.J. Ward and A.J. Fryers, researchers at Plessey Research Limited (Caswell, Northamptonshire, England), the section with the greatest effect on the speed of the conversion process is the reference DAC.

Saul, Ward and Fryers describe a monolithic 8-bit DAC which employs successive approximation techniques to obtain a full-scale settling time of less than 5 ns. The chip contains a precision voltage reference, a reference amplifier and a latched high-speed (1.3 ns) comparator, which should prove useful in the feedback loop of a multichip a/d converter. The on-board current amp has a 3-dB bandwidth of 40 MHz.

For these rapid speeds, the IC is constructed with special attention to component matching and very fine line widths. Ion implants achieve an F_T of approximately 5 GHz; and the resistors match to within 0.1%. Transistor bases and emitters are implanted in a 2.6-μm epitaxial layer. Base width is typically 0.14 μm and emitter depth is 0.3 μm. The ultimate chip



Multiple current sources provide high-accuracy and speed. Plessey's 8-bit DAC settles in 5 nS.

size is 1.7 × 1.8 mm.

The processing provides a current source format (Fig. 2) that yields high accuracy with minimal switching times. Settling takes place within 5 ns, with an accuracy of ±1/2 LSB. The reference source is controlled by precision resistors rather than buried zeners. However, the temperature coefficient of this reference is easily within 25 ppm/°C from −55 to +125 C.

The Plessey researchers believe that many features of the high-speed 8-bit DAC can help to build 10 and 12-bit devices. Although only a few manufacturers are looking at 12 and possibly 16-bit single-chip converters, these few are undoubtedly major competitors seeking monolithic integration.

12-bit monolithics

Prominent among them is National Semiconductor (Santa Clara, CA). The company's 12-bit a/d converter has microprocessor I/O capabilities that approach, and in some cases exceed, the capabilities of board-level data-acquisition systems. J. John Connolly and Thomas P. Redfern will describe a 12-bit-plus-sign monolithic a/d converter, which employs the successive approximation technique. The key to the success of the conversion process is a comparator with sampled multiple inputs.

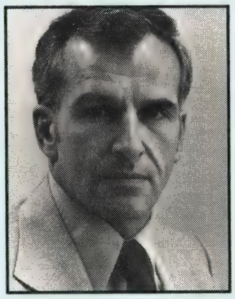
According to Connolly and Redfern, sampled data techniques prevent overloading of the comparator and substantially improve accuracy, response time, stability and noise. As Fig. 3 indicates, the comparator accommodates several different inputs. In operation, the analog input voltages are compared with the analog voltages generated by a pair of on-chip 6-bit DACs. Each DAC generates a matrix of 64 voltages from a single positive reference supply. Laser-programmable memory devices (LPROM) on the chip determine the sign and magnitude of the correction voltages. Out-board capacitors scale the multiple differential voltages for the comparator input, and successive-approximation signal routing provides a 50 μs comparator response to within ±1/2-LSB.

The sign of the differential inputs is determined by the sampling rate, relative to an autozero time at the comparator. This procedure eliminates the need for 13-bit generation.

The CMOS monolithic device consumes very little power—25 mW—from the total power line, including V_{REF} (5 V), analog V_{CC} (5 V), digital V_{CC} (5 V) and V_{EE} (−5 V) supplies. The converter interfaces directly to popular microprocessors, such as the 8080, Z80 and 6800.

As the monolithic 12-bit converter is being presented by National, a three device approach to 12-bit, a/d will be discussed by George Erdi of Precision Monolithics, Inc. (Santa Clara, CA) in the session on data acquisition. Like Connolly and Redfern, Erdi believes that the most important unit in the converter is the voltage comparator. Unlike the National Semicon-

Design wizardry in linear ICs



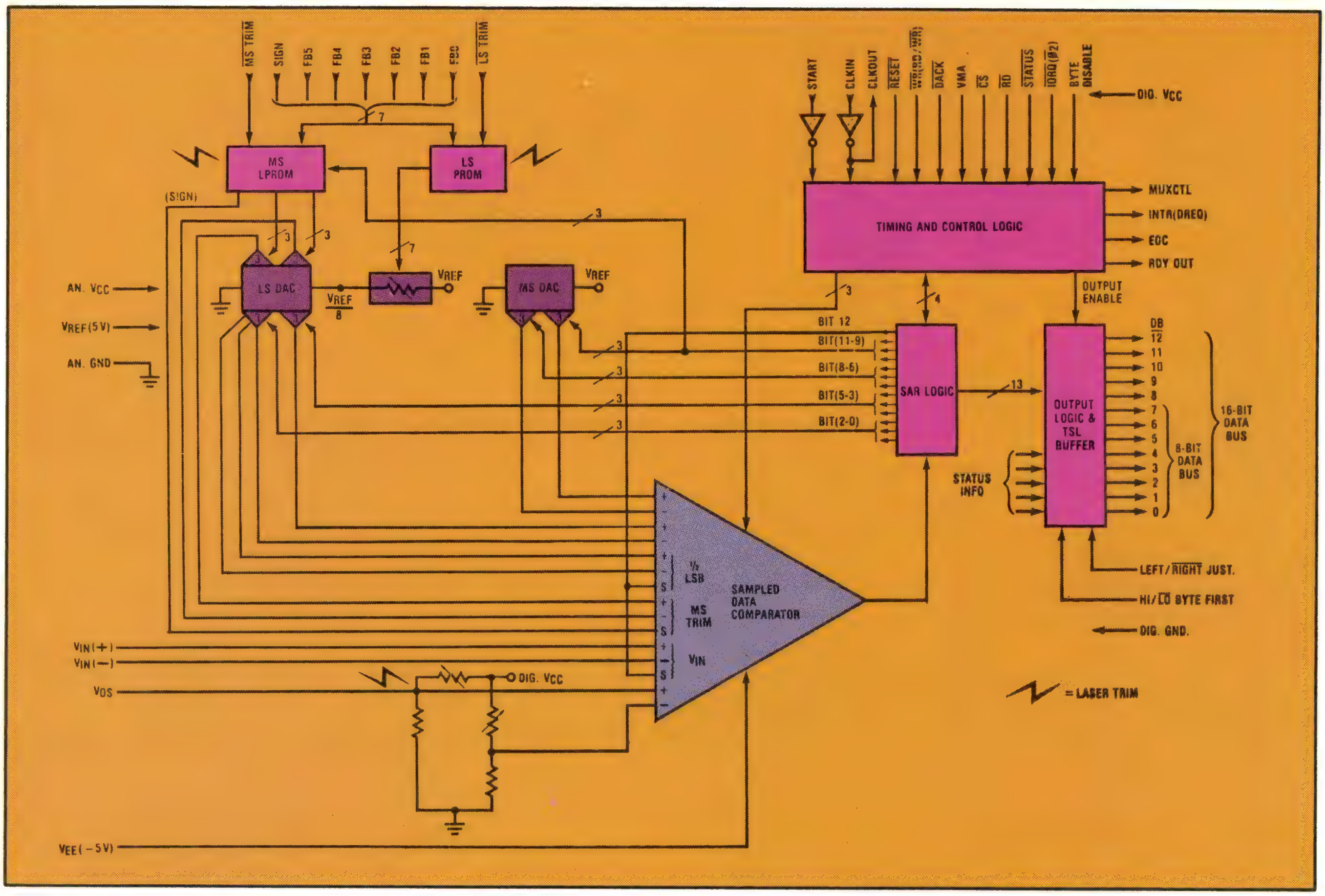
Monolithic integration—producing better on-chip conveniences, accuracy and resolution—and the challenge of new application areas will dominate analog circuit design this year and in the near future, according to Paul Brokaw, Division Fellow, at Analog Devices (Wilmington, MA) and Chairman of the ISSCC session on Data Acquisition Components.

Among on-chip conveniences, memory-storage on data-acquisition components will facilitate data sampling and deliver continuous reference information. As Brokaw says: "You'll find converters that will take several measurements and store the data internally; when you're ready, you can get all the data at once." Programmable gain amplifiers will simplify the data collection process by conditioning analog signals on the chip. Conveniences like these make for easier interfacing with microprocessors and turn the data acquisition component into what Brokaw calls a "cookbook part"—ready to use. "We can arrange the device," Brokaw says, "so that you don't have to be a wizard to get the best performance out of it."

In addition, converter circuit designs are advancing towards greater accuracy and resolution, by getting higher bit capacities. However, every additional bit will not only raise the cost of the converter but also require greater accuracy in every analog component. Thus, Brokaw suggests, designers will be seeking the best accuracies obtainable with a given bit capacity. This accuracy is affected by on-chip processes, independent of the bit resolution. "We haven't run out of resolution," Brokaw says, "but you'll probably see more accurate devices on a single chip."

For specialized application areas, such as video recording and editing, improving converter speed may produce a data "pipeline" process, taxing both MOS and the traditional parallel processing schemes to provide the necessary speeds. "Analog VLSI," according to Brokaw, "will require trade-offs between device complexity or density—lots of transistors—for some other quality like speed." Alternatives will come from a handful of clever designers.

Brokaw identifies a more exciting design area, and one which has been unexplored until recently: the application of monolithic filters; for example, in telecommunications and pulse code modulation. Here, a suitable time constant is created, not by finding the absolute values of filter components, but by adjusting the ratios between passive components in a filter network. IC filters using external timers and ratio-matched components will be inexpensive and compact, and will open up opportunities for innovation by IC designers. As Brokaw says, "ICs and filters have finally come together."



A multiple-input comparator is the key to the monolithic 12-bit a/d converter from National Semiconductor. Two on-chip DACs (upper left) deliver high-resolution analog references with laser-programmable memories.

ductor device, however, the PMI converter isolates the voltage comparator chip to upgrade its noise performance and to establish limits on the errors from offset voltage, offset current and voltage gain. Consequently, the comparator error in 12-bit conversion is typically less than 0.1 LSB, while the worst-case error sum is less than 0.2 LSB.

The new comparator uses a standard junction-isolated process, with a p^- implanted tub, containing a buried zener to create a three-dimensional low-noise level-shifter. The zener pockets also minimize epi capacitance along the signal path by tying it to the positive supply. A total of 75 transistors and 40 resistors populate 2300 sq mils.

The comparator's latch function locks the output for sample-and-hold observations. The latch circuit operates within 16 ns.

Juggling act

Analog converters increase their operating speeds and on-chip conveniences (such as latching comparators) without decreasing other performance parameters; but the design of operational amplifiers usually demands trade-offs. The speed or frequency bandwidth, for example, cannot be increased significantly without decreasing the gain. When sensitivity increases, so does the noise and the offset drift. Op amp designers get lots of practice in juggling specifications, such gain and bandwidth.

Some devices, however, show improvements in several different specifications—without a price increase. One such device is a linear instrumentation amplifier from National Semiconductor, presented by Carl Nelson. The op amp design cascodes super-Beta input transistors to produce pin-programmable gain in excess of 1000, with a common mode rejection of about 140 dB.

Many external parts (ordinarily used to control feedback loop gain, bias, offset voltage and other factors) are incorporated onto the chip and trimmed to spec. As a result, input offset voltage is less than 20 μV, and the input offset current is less than 0.5 μA. Power consumption is also low: Bias current for the input is 2 nA. Output voltage noise is less than 600 μV/Hz. The gain linearity for the entire IC is better than 0.01%. The gain-bandwidth product is either 150 kHz, with a gain of 10, or 30 kHz with a gain of 1000.

The same on-chip trimming techniques have reduced the offset voltage and drift, as well as the bias currents, in the National LM11 op amp, presented at the conference by Robert Widlar. The IC (ELECTRONIC DESIGN, Dec. 20, 1979, p. 44), can replace existing 8-pin devices with 100-μV input offset, 1-μV/°C drift and little more than 20-pA bias current. ■■

ISSCC Report continues on p. 57

Intelligent performance.

The 20 or 80 megabyte Burroughs FD 210 fixed disk subsystem is the newest member of our growing family of intelligent, compatible peripherals for OEM's.

This unit has an average access time of 35 ms and a transfer rate of over 7 million bits per second. An in-built microprocessor controller lets you select the interlace factor to match your system transfer rate. The controller performs high level functions such as asynchronous file search and off-loads the following tasks from your system:

- Track seek and sector location
- CRC generation and check
- Sector relocation
- Error detect/correct
- Confidence/diagnostic tests

By working with a storage subsystem, not just a drive, you get your product to market quickly and easily. The FD 210 has a simple parallel interface and command set for fast integration with your system. It's also interface-compatible with our new 6 megabyte floppy drive, so one interface suffices for both products.

Build the FD 210 into your system. Put it in your cabinet or choose the optional rack mount or free-standing cabinet.

Call or write **Burroughs OEM Marketing,** Burroughs Place, Detroit, MI 48232. (313) 972-8031. In Europe, High Street, Rickmansworth Hertfordshire, England. Telephone 09237-70545.

Burroughs

CIRCLE NUMBER 22 FOR GENERAL INFORMATION

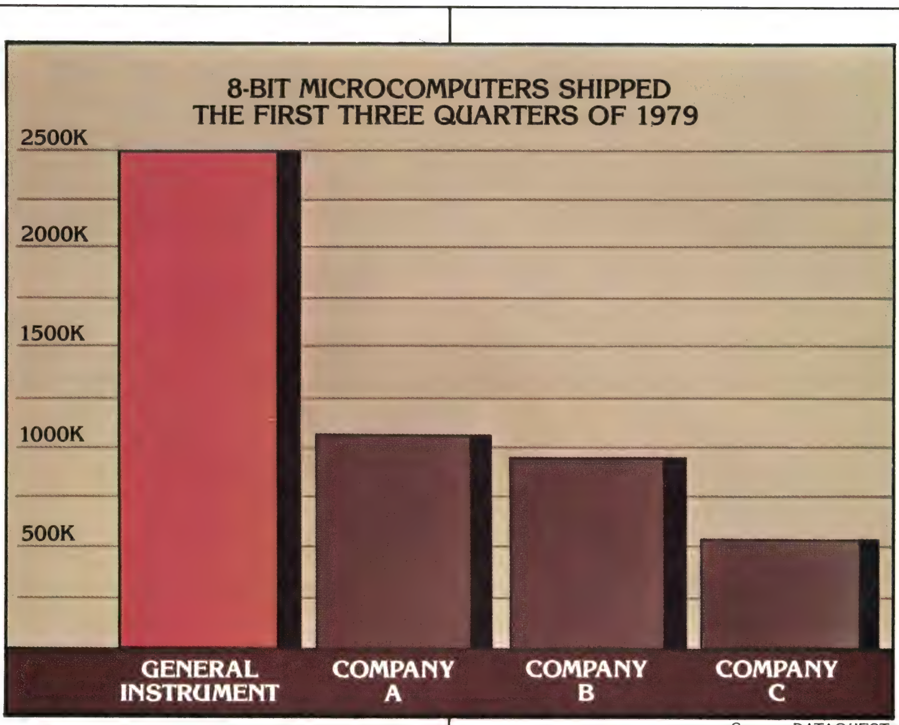
CIRCLE NUMBER 23 FOR DETAILED SPECIFICATIONS

We didn't get to the
the most 8-bit

The record speaks for itself. An independent survey revealed that during the first 9 months of 1979 General Instrument had topped all rivals by delivering over two and one-half million 8-bit microcomputers. That's more than twice as much as our nearest competitor.

While it is a most impressive record, to be sure, it's a direct reflection of the success and acceptance of General Instrument's philosophy: To provide products of consistent high quality, backed by comprehensive support and customer service, at competitive prices. Simply stated, we deliver more 8-bit microcomputers, because our microcomputers deliver more to our customers.

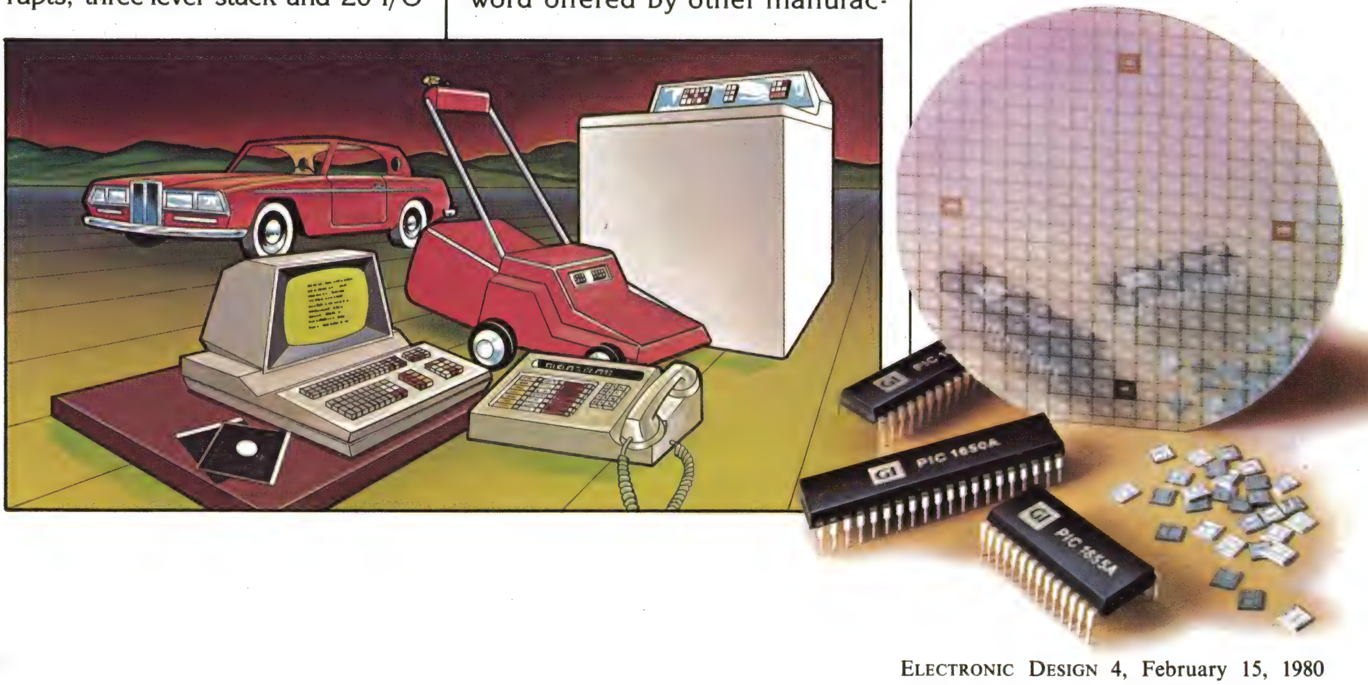
Specifically, our popular PIC family consists of the PIC 1650A with 512, 12-bit words of Read-Only-Memory, 32, 8-bit bytes of RAM, 32 I/O lines, real-time clock counter and two-level stack, packaged in a 40-pin DIP. The PIC 1655A is a reduced I/O version, 20 I/O lines, packaged in a space-saving 28-pin DIP. Another version, the PIC 1656, has both external and internal interrupts, three-level stack and 20 I/O lines in a 28-pin DIP. A development microcomputer, without the ROM, is also available.



Source: DATAQUEST

All PIC series chips feature a powerful 12-bit instruction set, instead of the usual 8-bit instruction word offered by other manufacturers, which allows applications with far less ROM.

So much for what we make. What our customers make of it is something else again. Our 8-bit microcomputers have proven them-



top by just delivering microcomputers.

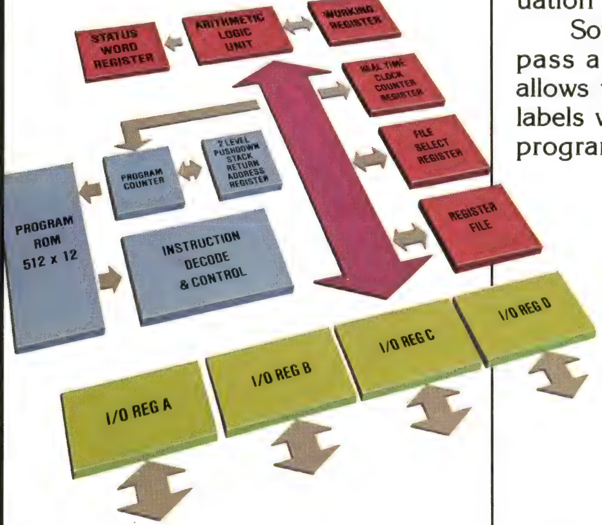
selves in a wide variety of applications, including vending machines, consumer appliances such as washing machines and vacuum cleaners, electronic games, keyboards, display drives, TV/radio tuning systems, industrial timers, motor controls, security systems and automotive dashboard instrumentation. And as long a list as we may come up with, it still isn't long enough, because even as you're reading this, someone is designing a PIC into yet another challenging product application.

No matter how good a product may be — and ours is second to none — it needs the proper support to realize its full potential. Which is why we offer a complete, inexpensive set of hardware and software aids. This helps our customers in their design, development, and evaluation of a particular application.

Software includes PICAL, a two-pass assembler program, which allows the use of mnemonics and labels when writing the application program. By attaching our PICES In-Circuit Emulation System to any host computer, you instantly have a single-station PIC development system. Rounding out the support group is the PFD Series of PIC Field Demo systems which emulates the PIC Product Line, enabling the demonstration of an application program in the field before it's committed to a masked ROM.

And, as you'd expect, we provide a complete library of information documenting all there is to know about our systems, including a PICAL User Manual, PICES Data Manual, PIC Handbook and PFD Series Data Manual — all yours for the asking. For more information, write or call General Instrument Microelectronics Ltd., Regency House, 1-4 Warwick St., London W1R 5WB, England, or call 01-439-1891.

We help you compete.



GENERAL INSTRUMENT

Microelectronics Applications Handbook 1980
PICES
PICES MODULE
PFD 1000/1010 PIC FIELD DEMO SYSTEM DATA MANUAL
PICES PIC IN-CIRCUIT EMULATION SYSTEM DATA MANUAL
PICAL PIC CROSS ASSEMBLER MANUAL
GENERAL INSTRUMENT

Today's Answer for Non-Volatile Random Access Memory...

...Is CMOS RAM With Lithiode™ Battery Back-Up...

. . . the patented Catalyst Research Lithium-Iodine cell that you can count on for **years of continuous memory retention.**

The LITHIODE is a long-life primary battery that never requires recharging or battery replacement and its solid state design is completely safe under short circuit or voltage reversal conditions. A similar version has been used in over 200,000 human cardiac pacemakers.

With a LITHIODE/CMOS RAM combination, you get the benefits of proven, multi-sourced RAM memory in a non-volatile form.

™Trademark of Catalyst Research Corporation

Add that to its low power, single voltage operation and its high speed, unlimited write cycles and random access capability and you have the answer.

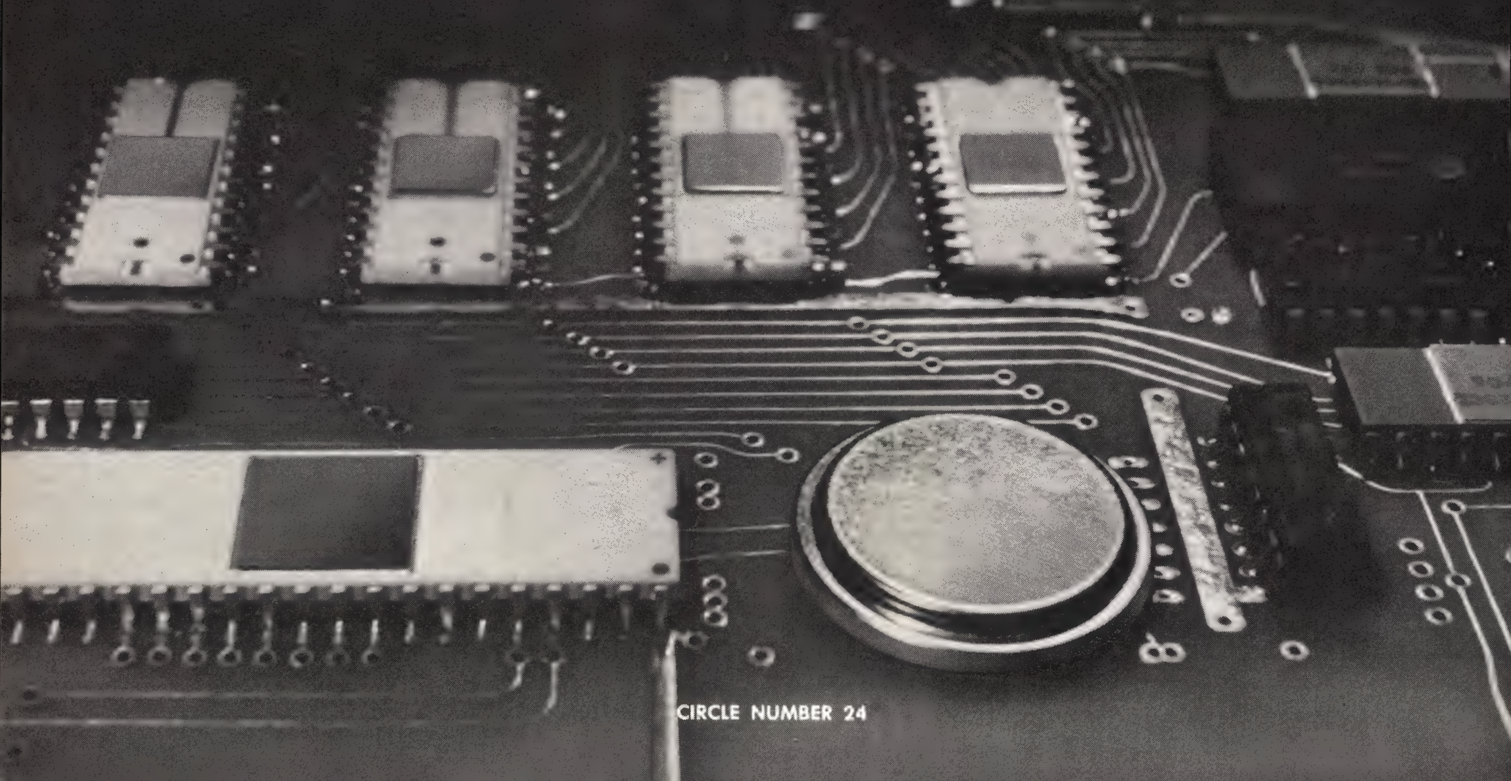
SO IF YOU NEED NON-VOLATILE RAM . . . SELECT CMOS RAM WITH A CATALYST RESEARCH LITHIODE BATTERY . . . TODAY.

CONTACT US FOR A LIST OF CMOS RAM's SUITABLE FOR USE WITH OUR STANDARD LITHIODE CELLS.

CR

CATALYST
RESEARCH
CORPORATION

1421 Clarkview Road, Baltimore, Md. 21209
(301) 296-7000



CIRCLE NUMBER 24

Telecomm LSI climbs in density, voltage

Combine the benefits from advances in processing, circuitry and architecture, and the result is a bumper crop of ICs for both general and special-purpose communications. High-voltage, densely packed analog chips are blossoming while some of the new digital offerings are truly VLSI—with as many as 45,000 transistors.

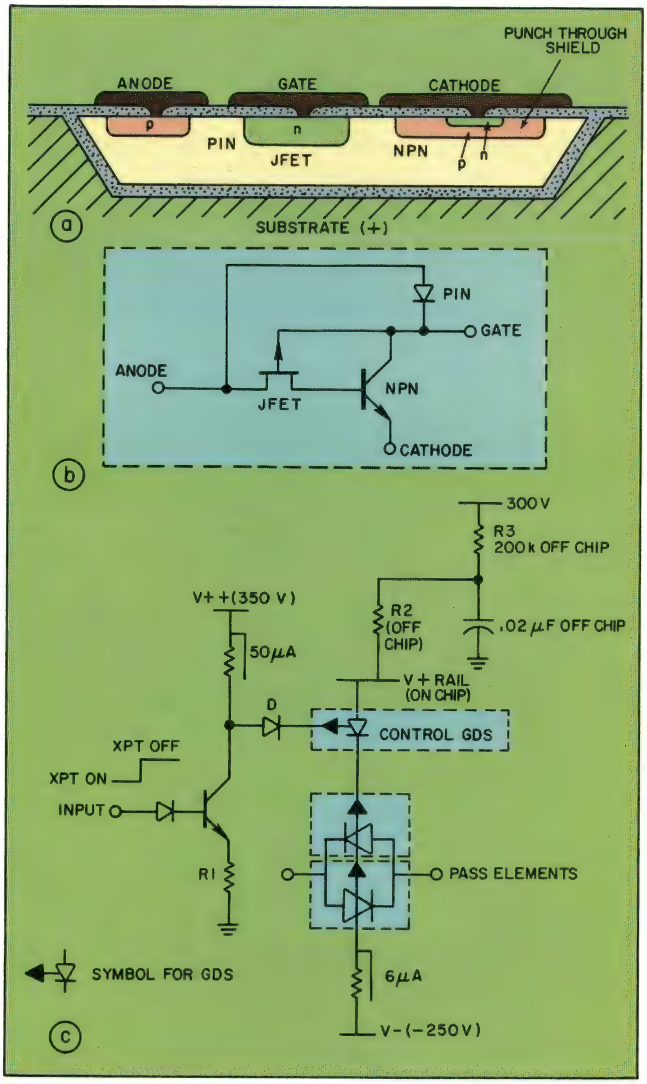
This mixed harvest of communications ICs is making the ISSCC a veritable banquet for comm-equipment designers. Highlights include:

- A high-voltage, bidirectional crosspoint switching matrix
- Two solutions to subscriber-loop interfacing problems
- VLSI implementations of an adaptive echo canceller and a signal processor optimized for real-time communications
- Communications filters—both fixed and programmable units—that exploit improvements in switched-capacitor and gyrator-based circuits.

Concentrating up to ten subscriber-loop lines into one line-interface unit is on the verge of passing from mechanical, space-division multiplexing into the low-cost, small-size, high-reliability realm of ICs thanks to a high-voltage crosspoint switching matrix introduced by Bell Labs (Murray Hill, NJ). The breakthrough chip, described by Peter W. Shackle, supervisor of Bell Labs' high-voltage IC design group, derives unique qualities from a novel circuit, a gated-diode switch (GDS).

The chip version fully satisfies the requirements for a telephone-loop switch, Shackle reports. It can block ±500 V, conduct 1-A surges and interrupt normal 48-V telephone-loop dc.

Sid Adlerstein
Communications Editor



Diffusions create the electrodes and guard ring of the gated-diode switch (a) in the Bell Labs (Murray Hill, NJ) crosspoint. The GDS circuit is made up of a pin diode, a JFET and a bipolar transistor (b). Two transmission GDSs are controlled by a third GDS in each element (c).

The matrix consists of four crosspoint pairs—eight transmission GDSs, all told—packed onto 3 × 3.6-mil^2 of silicon. Each GDS unit contains three elements: a JFET, a pin diode and an npn transistor.

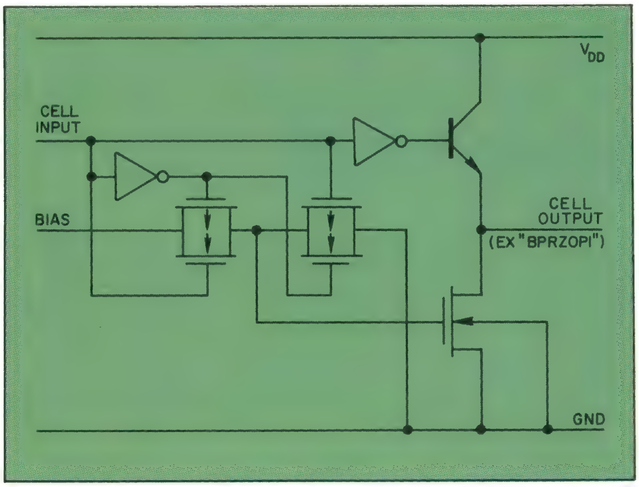
The JFET source and drain also serve as the GDS anode and shield, respectively, while the JFET gate is the GDS gate. The diode connects the GDS anode and gate. The bipolar transistor's emitter, base and collector are the gated-diode switch cathode, shield and gate, respectively.

Two GDS units, connected back-to-back with a gate in common, produce the bidirectional blocking and conduction for each call circuit. The chip's polysilicon substrate is biased at 350 V so that biasing the gate at 300 V produces the off state. This biasing generates electric fields from the substrate and a top-gate contact that produce a 240-V minimum-potential region under the top gate. This region's potential blocks anode-to-cathode conduction for terminal potentials up to ±250 V. A diffused p-type shield prevents punch-through from the gate junction to the cathode. Connecting the n-type gate contact to a 6-μa current sink produces the on state.

The JFET and npn transistor's emitter-base junction start the conduction process, thereby turning on the bipolar transistor. Most of the current then goes through the diode and the npn collector. As the current level rises, the npn-transistor gain falls below unity while the JFET grows increasingly conductivity modulated until most of the current goes through the JFET and the emitter-base junction. For even higher currents, the npn transistor's effect decreases. Then conduction occurs primarily via double injection from the anode and cathode with conductivity modulation of the p-type region in between. With conduction established, the current sink at the gate no longer affects the GDS and can be removed.

Breaking conduction only requires reapplying a positive gate bias. In the crosspoint IC, a third control/GDS manages the bias for the other two.

Telephone-subscriber loops present special problems, which can be solved more easily with ICs. For example, each loop in a digital PBX telephone system interfaces with both a station set (telephone) and a PBX line card. A line-interface IC that works at both ends of the loop greatly simplifies matters. As described by Alberto Boleda, manager of BCS terminal hardware development at Bell Northern Research (Palo Alto, CA), one such chip can handle up to four channels in each direction simultaneously.



The ouput in BNR's line-interface chip is differential—it develops across a pair of circuits, each consisting of an npn and NMOS transistor pair.

Subscribing to ICs

A logic input chooses one of two operating modes: line-card (LC) or digital-station-set (DSS). In LC mode, the chip interfaces the PBX backplane to the digital transmission line while LC-generated signals control operation. In DSS, the chip interfaces a codec, the set controller and an optional PCM channel to the digital transmission line. When working with the set, the chip internally generates the required control signals from the incoming pulse stream. The chip sends PCM signals to and receives them from a transmission line in bipolar-return-to-zero (BPRZ) format, typically at 128 kbits/s.

The output signals are driven differentially from a pair of drivers, each containing an npn and a current-limited NMOS transistor. According to Boleda, combining a bipolar transistor and a FET handles short circuits while taking up minimum chip acreage.

The line-interface IC also generates codec and μC control signals in the DSS mode. It accommodates codecs and controllers with differing control requirements and voltage levels. A programming input selects the codec clock rate, and an on-board zener reference provides programmable, high-output logic levels. The chip, integrated with Northern Telecom's CMOS II isoplanar technology, nominally dissipates 120 mW using a 12-V source.

Another subscriber-loop challenge is to interface analog telephone-subscriber loops with a line card that provides BORSCHT functions (Electronic Design, April 12, 1979, p. 86). Though substantial effort has gone into developing complete, monolithic subscriber-line interface circuits, one-chip solutions have not become available so far. In the interim, integrated circuits that perform some of the loop-interfacing functions are being developed.

A good example is a floating power conversion scheme revealed by Laimonis Freimanis of Bell Labs in Naperville, IL. It operates under the control of a low-voltage, complementary-bipolar IC. Floating the power converter produces several considerable advantages, including immunity to 60-Hz longitudinal induction and common-mode power crosses, and isolation from 1000-V loop transients at the low-level electronics in the switching and control system. In addition, small 200-V SCRs may be substituted for relays in the customer-loop ringing and testing circuits; attenuation of battery noise and crosstalk

New telecomm LSIs will slash power

"Next year's telecommunications ICs will provide enhanced performance at reduced power levels," predicts Dave Sealer, Telecommunications Department Manager at Mostek, Carrollton, TX. Among the principal benefactors will be switching and transmission equipment for digital telecomm systems. Power dissipation is particularly crucial in many of these applications because power is on continuously.

In some retrofits, ICs replace passive components, such as filters, that had no power at all brought to their cards. Low-power ICs will let packaging get denser and lifetimes longer. These features are particularly significant in telecomm installations, where forced-air cooling is impossible and convection cooling is all an equipment designer can count on.

The principal method of processing low-power ICs has been CMOS. Thus, Sealer foresees more CMOS chips; but he also predicts that recent developments in n-channel technology will be harnessed to produce very low-power, dense ICs.

One problem that continues to elude LSI technologists is the set of subscriber-line interfacing functions. The requirements for tight performance specifications, for circuitry higher than 300 V and for uncomprisingly high telecomm reliability—all combine to make the SLIC a very tough nut to crack. Sealer looks to creative approaches for ways to meet the high-voltage and high-current functions. Perhaps a single IC is not the most cost-effective approach to siliconizing the SLIC.

In his enthusiasm about the future of LSIs, Sealer points out that dedicated chips are not the only devices to have found a place in telecomm. The trend toward higher reliability from redundancy, greater compactness, better performance and more functions, at low cost, has already ensured that telecomm equipment will make extensive use of microcomputers and memory chips. For an example, Sealer cites the modern digital PBX. He considers the enormous investment in local-loop plant as a challenge to creative solutions that will bring forth such developments as moving the digital interface back towards the subscriber. All the while, however, Dave keeps a prudent eye on cost—"Successful telecomm ICs must give the user what performance he needs at a price he can afford."

from the audio-loop signal is improved over conventional magnetic battery feeding, and heat dissipation is reduced when powering short loops without sacrificing long-loop performance.

The converter chip can operate in one of three modes: full-power, on-hook or ringing. In the full-power mode, it supplies a controlled current to the microphone, collects rotary-dial pulses, supervises switch-hook signaling and generates a voltage proportional to the loop resistance. While servicing an on-hook loop, the converter consumes only about 50 mW. In ringing or loop-testing modes, both audio and battery feed are disconnected from the loop by stopping the converter and opening an SCR.

Over in the long-haul sector, echoes can be as annoying an impairment as low volume or noise, especially in systems using PCM transmission. Because subjective annoyance increases with the delay time, satellite circuits head the list of problem systems—inherent delay is 270 ms. And worse, some speech energy returns to the speaker, delayed by 540 ms.

To help improve long-haul voice service, Y.S. Chen and D.L. Dutweiller of Bell Labs at Murray Hill and Holmdel, NJ, have developed a VLSI echo canceller, to be installed in pairs. The chip adaptively cancels echoes by subtracting an echo replica from the return signal. Inputs and outputs to the chip are digital, in either 8-bit μ-law or A-law format.

Within the IC, a tapped delay line stores many of the most recent samples of the far-end speech. A tap weight multiplies the signal at each position along the line. The chip's memory is a 2704-bit serial shift register, which uses a two-phase dynamic circuit that, according to Chen, minimizes power drain. Made from enhancement-mode NMOS, the chip nominally consumes 750 mW from 5 and 12-V supplies.

The eight transistors and two capacitors that service each bit occupy only 6.24 mil^2 of silicon. The rest of the chip contains random logic that uses about 3300 gates. All told, the chip covers just 313 × 356 mil^2, so it fits into a 24-pin DIP.

In addition to special functions, VLSI chips can handle general-purpose responsibilities in communications-system design. Add programmability to the enormous processing power that can be concentrated in digital VLSI, and the result could be chips that are single-handed microcomputers, sporting instruction sets and addressing optimized for the real-time signal processing commonly required in filtering, modulation and demodulation for communications.

Such a programmable digital signal-processor chip exists. Moreover, it can decode an instruction, fetch data, multiply 16 by 20 bits and accumulate the resulting 36-bit product in one 800-ns machine cycle. According to J.R. Boddie of Bell Labs in Holmdel, the 45,000-transistor, depletion-mode NMOS signal processor needs no help operating as a low-speed modem or dual-tone multifrequency receiver. In addition, its arithmetic precision is up to handling numerous voice-grade applications.

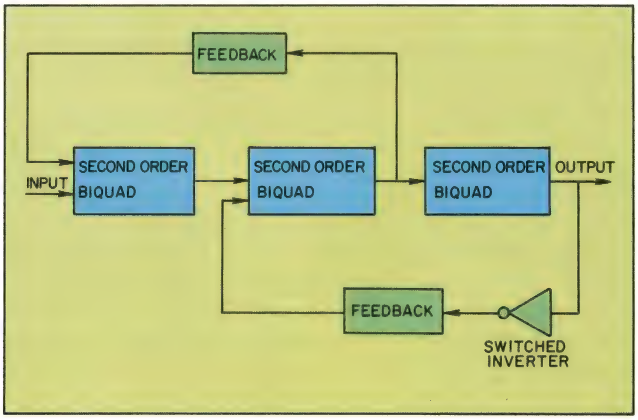
With the 800-ns cycle time, based on a 5-MHz clock, the processor can execute a four-coefficient algorithm for a two-pole, two-zero, recursive filter section in 3.2 μs or the same algorithm for one tap of a nonrecursive filter in 0.8 μs, says Boddie. This leads Boddie to believe that the chip could realize about 39 second-order recursive sections at 8-kHz sampling. Adding to this the device's adaptable and separate serial input and output ports along with flexibility stemming from an on-chip program ROM, Boddie envisions the chip's becoming the basic signal-processing element in many telecomm systems.

Filtering in LSI

Meanwhile, integration on a smaller scale is keeping up with one of the more ubiquitous communications elements: the filter. Many entries are cropping up at ISSCC, based on circuit concepts suited to particular frequencies.

For video up to 6 MHz, Kenneth W. Moulding of Philips Research Labs in Redhill, Surrey, England, introduces a gyrator-based filter chip that separates TV-receiver video-signal components. According to Moulding, the chip needs neither tuning nor alignment, has temperature-stable Q factors and is suitable for mass-production in a standard bipolar process. Gyrators, terminated with junction capacitors, simulate inductance-capacitance filtering resonators. The voltage dependence of the junction capacitors provides the means for automatically tuning each filter response.

First, a two-stage sound trap strips the intercarrier sound from the composite video signal, providing a low-impedance output of teletext. Second, a single-gyrator resonator separates the luminance and chrominance signals. In the sound channel, a bandpass pair provides the selectivity needed. The chip automatically tunes its five filter resonators by aligning an auxiliary gyrator resonator with the TV decoder's crystal oscillator.



Each of the two sixth-order bandpass filters are made up of three second-order biquad sections in a leapfrog configuration in Mitel's DTMF band-splitting filter.

The automatic tuning leaves at most 10-kHz error. Temperature dependence of the center frequency is 0.006%/°C, and signal-to-noise ratio measures better than 80, 70 and 60 dB for teletext, luminance and chrominance channels, respectively.

The 11-mm^2 standard bipolar chip, with just 567 components, is far from VLSI. However, its six gyrators are all laid out the same, with 14 transistors each. This takes up just one third of the chip area.

Another filter-space problem, this one at voice-channel frequencies, has been integrated away. First, the long time constants required for filtering were successfully integrated onto silicon by simulating high values of resistance with switched capacitors. But that left banks of switched-capacitor filters requiring both considerable power and chip area. Both problems have been solved by sharing two operational amplifiers among several filter channels, says Patrick W. Bosshart, a member of the CCD signal-processing group of Texas Instruments (Dallas).

Bosshart's scheme switches n pairs of integrating capacitors into the two op amps once every clock period, thereby creating a bank of n filters. For each channel, the filter is stepped through a computing cycle in each clock period. Each channel's transfer function can be tailored by using different switched-capacitor values.

From an original breadboard containing four second-order filters, Bosshart has designed a 2.5-mm^2 test chip that incorporates 20 second-order sections. With only two op amps, Bosshart expects the relatively small chip to draw less than 25 mW.

Switched-capacitor filtering techniques are also being applied in chips to band-splitting filters for DTMF receivers. Tom Foxall, manager of analog-circuit and filter-IC design at Mitel Semiconductor, (Kanata, Ontario, Canada), reports that a circuit built in the company's double-poly oxide-isolated CMOS process takes advantage of the second polysilicon level to get precise ratios of linear capacitances to be fabricated. Meanwhile, the oxide-isolated CMOS produces high-speed logic that can be packed densely—no guard bands are needed. The circuit can operate from a supply ranging from 4.5 to 15 V.

Integration also helps reduce both power and noise in switched-capacitor PCM-channel filters. William C. Black, Jr., a doctoral candidate at the University of California at Berkeley working with National Semiconductor (Santa Clara, CA), has used an advanced double-poly silicon-gate CMOS process to incorporate the transmit, receive and line-frequency rejection filters on a 129 × 180-mil^2 die. All precision filter sections use bottom-plate switched-capacitor ladder filters to ensure nonsensitivity to switch and substrate parasitic capacitances.

The PCM filter chip contains 21 amplifiers, 14 switched-capacitor poles and eight continuous active R-C poles. With the power amps active, the chip draws less than 40 mW, less than 1 mW in standby. ■■

ISSCC Report continues on p. 63

Brand-Rex engineering goes to great lengths to satisfy critical customer needs for custom flat cables.

These products range from Tape Cable® (flat flexible cable) to ribbon cables and other constructions depending on electrical, mechanical and termination requirements.

Custom features include copper shielding for high frequency applications or tough outer jackets for UL listed external interconnections. Where termination is a special consideration, we offer a number of design options.

Customizing extends beyond construction to assembly systems. Jumper cables. Harnesses. Retractibles. Systems already terminated to PC boards.

Whether your flat cable requirements are standard or special, we would like to hear from you. For your copy of our new Flat Cable brochure, write to Brand-Rex Company, Electronic & Industrial Cable Division, Willimantic, Connecticut 06226.

BRAND-REX
ELECTRONIC AND INDUSTRIAL CABLE DIVISION

Brand-Rex Company Divisions
Abbott & Co.: electrical harnesses for industry
Brand-Rex Ltd. (Scotland): wire and cable
Electronic & Industrial Cable Division: wire and cable
Nonotuck Manufacturing Company: copper wire
Pyle-National Company: electrical connectors
Telecommunications Cable Division: wire and cable
Teltronics, Inc.: telecommunications products

BRAND-REX COMPANY, A PART OF Akzona INC.

CIRCLE NUMBER 25

CUSTOM FLAT CABLES...
BY THE MILE.

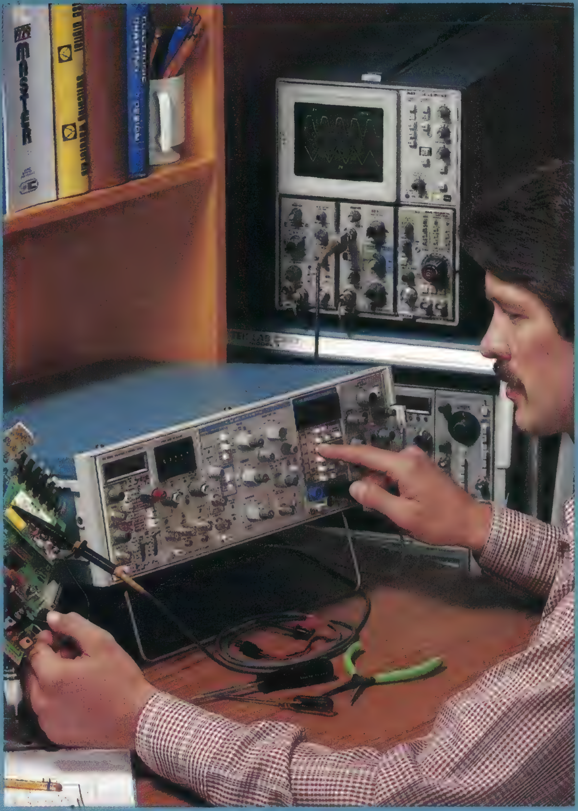
With TM 500, the setup's up to you.

Change it, rackmount it, bench it, roll it, carry it ...whatever's right for you.

Testing situations can change rapidly. Most test gear cannot. TM 500 gives you an answer to this long-standing problem. How? By letting you assemble your instrumentation in any combination and format that does the job best.

It's done through a series of nearly 40 interchangeable plug-in instruments that fit into any one of six mainframes. Including a sturdy rackmount. Or a hand-carried portable. Plus four different bench-top sizes. There's also a roll cart that lets you carry a scope along with two mainframes full of plug-ins.

Whatever way you want to go, TM 500 lets you do it. All mainframes accept all plug-ins. Everything from DMMs to scopes to generators. Up to six at a time.



With external rear connections in every mainframe to give you cable-free interfacing. There are even blank plug-in kits that let you construct your own special purpose instrumentation.

TM 500 also lets you change your setup along with your needs. Today's rackmount configuration can become tomorrow's portable testing outfit. It's all up to you. Simply switch your plug-ins around. No matter how you do it, you get the same dependable performance.

To find out more about TM 500, contact your local Tektronix Field Office, or write Tektronix, Inc.

TM 500 Designed for Configurability

Tektronix®
COMMITTED TO EXCELLENCE

Tektronix, Inc.
P.O. Box 1700
Beaverton, Oregon 97075
(503) 644-0161
Telex: 910-467-8708
Cable: TEKTRONIX

Europe, Africa, Middle East:
Tektronix Int'l., Inc.
Postbox 827
1180 AV Amstelveen
The Netherlands

DC 505A UNIVERSAL COUNTER / TIMER
EVENTS DELAY COUNT
DD 501 DIGITAL DELAY
PG 508 50MHz PULSE GENERATOR
DM 501A DIGITAL MULTIMETER
PS 503 A DUAL POWER SUPPLY
POWER

Copyright © 1979, Tektronix, Inc. All rights reserved. 858

ISSCC

Dedicated LSI chips come out as costs drop

The second generation of LSI is special, in more ways than one. First-generation development costs were so high, developers had to concentrate on general-purpose, mass-market devices such as microprocessors, solid-state memory arrays and data converters to spread the costs among many units. But development costs have come down enough to open production lines for specialized LSI circuits with medium and even low market volumes. The ISSCC will showcase this new, two-pronged generation:

- Medium-volume consumer LSI devices include a CCD-implemented color-TV comb filter, a ROM-controlled radio tuner and an I^{2}L servo for video recording.
- Low-volume but cost-tolerant LSI devices include CCD image sensors and such implantable biomedical devices as an I^{2}L-improved flow meter and a low-power body-fluid pressure sensor.

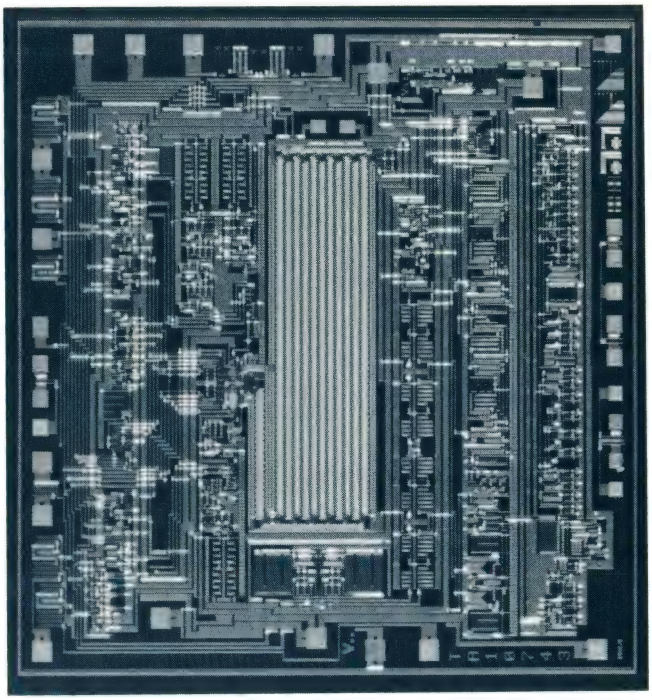
The CCD comb filter is the first mass-produced CCD-IC consumer product, according to Walter F. Kosonocky and Donald J. Sauer of RCA Laboratories (Princeton, NJ). Incorporated into RCA's 1980 ColorTrak TV models, the filter combines a CCD with a 1-H (horizontal-line time, 63.5 μs) delay line with all the necessary linear and digital support circuitry on one chip. A double polysilicon, N-channel, self-aligned gate process puts it all together.

The chip's 682.5-stage, two-phase serpentine CCD, operating at a clock frequency of 10.7 MHz (three times the color subcarrier's 3.58 MHz) provides the 1-H delay. NMOS support circuitry does the rest—clock drivers with automatic 50% duty cycle, a timing generator for variable-gain inputs and sample-and-hold outputs, self-adjusting CCD input and output-bias circuits and linear-output video amplifiers.

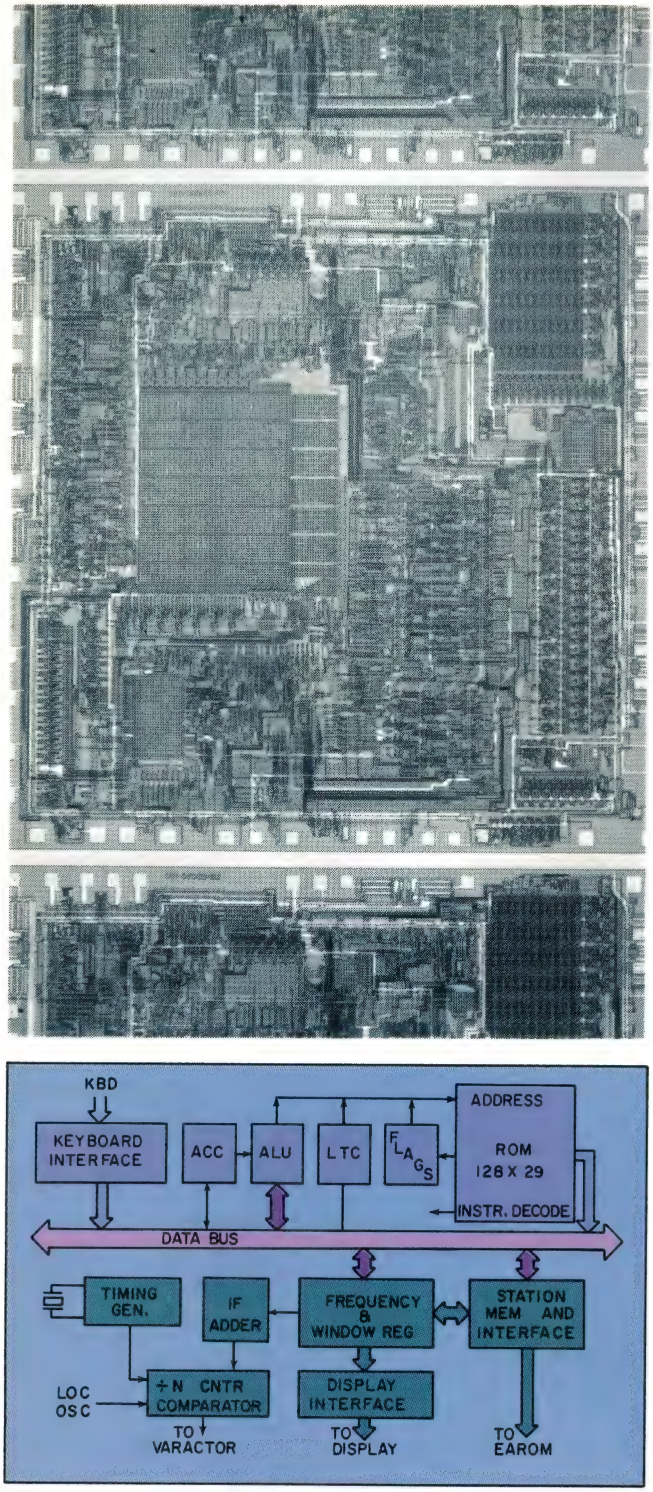
Morris Grossman
Senior Editor

LSI technology is also finding a home in radios, especially high-fidelity and automobile types.

Electronically tuned AM and FM radios employ digital PLL principles. Although multichip circuits can be used to implement PLLs, a single-chip LSI array described by R. Herber and L. Penner of General Instrument Corp. (Hicksville, NY) can do the job



RCA's CCD comb filter, the first mass-produced CCD-IC consumer product, fits the delay and all NMOS support circuitry on a single LSI chip.



Electronically tuned AM and FM radios can now be controlled by this digital PLL, which General Instrument has put on one specialized LSI chip. Because of its programmable μP control, this circuit, though specialized, is still very flexible.

even better. Not only are mechanical-tuner mechanisms eliminated, but advanced control features, hitherto unavailable, can be provided.

Single-chip is better

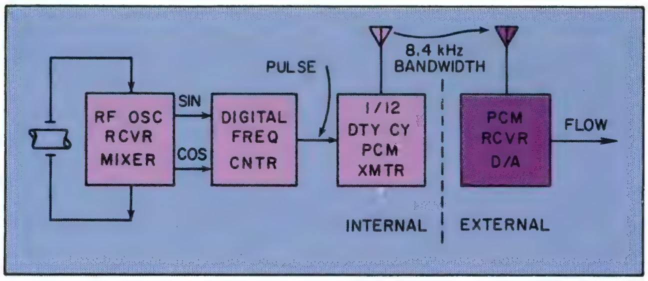
Although the chip is specialized for radio tuning, its I/O characteristics and operating procedures are controlled by a microprocessor that is programmed by a ROM organized into 128 words of 29 bits each. Varying the program can change the operating features.

An on-board, 2.6-MHz crystal oscillator provides timing. Reference frequencies for the PLL, one for AM and another for FM, are generated by a timing chain driver, which is programmable between 780 Hz and 100 kHz. Circuits for driving output displays and handling an input keyboard are also provided. The result? A dedicated, but flexible, LSI circuit.

Even more specialized is Sony Corp.'s (Tokyo, Japan) servo-control-system LSI chip for video recording. Mathematically similar to GI's PLL, Sony's servo system, however, is implemented quite differently. At the root is linear-compatible, bipolar I^2L technology, which, according to Kenji Nakano, one of the system's developers, should open the way to a range of future consumer applications.

Because I^2L is not fast enough to handle directly the 12-bit quantizing rate needed for a 200-Hz sampling frequency, the circuit is divided into two blocks—an 8-bit and a 4-bit. However, I^2L does make possible highly accurate PWM-type d/a conversion. The output frequency is more than ten times the sampling frequency.

I^2L also crops up in a specialized medical chip described by Thomas R. Harrison and James W. Knutti of Stanford University's Center for Integrated Electronics in Medicine (Stanford, CA). Low-power oper-



With one-tenth the power drain of former biomedical implantable transmitters, this Stanford University-designed unit on an LSI chip transmits body-fluid flow data across intact skin.

ation is vital for implanted measurement systems that transmit physiological data across intact skin. The key to success here is an a/d frequency counter implemented with linear-compatible I^2L. Using the chip along with a low-duty-cycle data encoder and rf PCM transmitter, an ultrasonic CW-Doppler flowmeter needs one-tenth the power of conventional circuits formerly used as transmitters.

Low power, high sensitivity

Low power is a key feature in another implantable biomedical device, this one heralded by Knutti and Craig S. Sanders. A capacitive pressure sensor complete with biasing circuit, pulse-period oscillator and output stage is formed on a single 2.4 × 3-mm silicon substrate. The device is not only 25 times more sensitive than any piezoresistive transducer, it's also more stable—hardly influenced by strain or temperature changes—and consumes 1% of the power. The same design can be used in automobiles, aircraft and other portable instruments.

What's more, the circuit needs just 20 μA from a 2.5-to-10-V source to operate the circuit; comparable piezoresistive units need more than 2.5 mA. Output, a pulse period proportional to applied absolute pressure, varies between about 136 and 157 μs for a pressure range between 0 and 300 mm Hg.

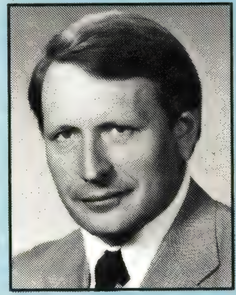
While Stanford University pursues the application of LSI technology to pressure sensors, Fairchild Camera and Instruments (Palo Alto, CA) works on image sensors. Michael G. Farrier and Rudolph H. Dyck have developed a 1030 × 128-element CCD image sensor for low light levels, as in a periscope camera. Designed with 20-μm-square sensing elements, the LOPATCH (for low-light-level, panoramic, time-delay-and-integration, charge-coupled image sensor) features up to 128 linear lines of integration and an active imaging area 20.6 mm long.

In addition to its capability at very low light levels, determined mainly by the noise (about 25 electrons) in its low-noise preamplifier, the unit has a wide dynamic range—an upper saturation level of 10^6 electrons/pixel—and a data rate of 10 MHz.

At low light levels, a floating-gate amplifier provides a conversion gain of about 10 μV per electron; at high levels, a resettable floating-gate amplifier takes the full saturation level, with a conversion gain of about 4 μV/electron.

Imaging is also the concern of D.M. Brown and H.K. Burke of General Electric (Schenectady, NY). Working in charge-injection imaging, they have come up with a technique that allows high-speed readout, while lowering fixed-pattern and temporal noise. The new technique has demonstrated pixel readout rates up to 8 MHz with low pattern noise on 128 × 128 test arrays. The goal is to achieve the high resolution, low noise and economical fabrication yield needed for TV recorder cameras, which require 500 × 500-pixel resolution to replace or compete with film. ▪▪

For CCDs, the future is in color



After ten years of deep involvement in charge-coupled-device technology, Walter F. Kosonocky, technical staff member at RCA Laboratories, Princeton, NJ, is finally seeing his efforts pay off with the widespread use of CCDs. Kosonocky, who served as the program chairman for last year's ISSCC, points out that CCDs are already appearing in imaging devices in black and white television cameras. The next wave of developments will center on their use in color TV cameras—the subject of two papers at this year's ISSCC.

The goal here is to develop a low-cost camera that could be used with a low-cost videotape recorder, which will eventually replace or at least compete with film in industrial and commercial applications.

"The basic technology is under control; the problem is how to get reasonably good yield with large chips," says Kosonocky. Size balloons from the need to pack upwards of 20,000 CCD imaging elements on one chip. The CCD chip used in the RCA black and white TV camera, for example, measures about 800 × 500 mils. Making it smaller would create a problem—poorer signal-to-noise ratio. Each imaging element produces lower output signals, while the noise does not decrease substantially, or at least in the same ratio.

At the same time, these black and white chips cost about $2000. But for a color camera, aimed at a broad market, the price must be much lower—less than $100, according to Kosonocky. Eventually that will happen and Kosonocky points to the traditional price reductions in semiconductor memories. Being roughly equivalent in complexity to a 256-kbit memory, the CCD chip should eventually follow the same price reduction curve.

At any rate, CCDs are finding use in signal-processing circuitry—Kosonocky is a co-author of a paper on a CCD-based comb filter for TV receivers. In the filter, now being used in many of RCA's TV receivers, the CCD delay line is on the same chip as the clocking and signal-processing circuitry.

"The CCD represents a small percentage of the total chip area, but it's essential," Kosonocky observes. "The comb filter requires a delay line for one horizontal TV line, and the CCD provides a good delay function."

PMI's OP-01 Can Save You From Drowning In A Pool of BIFET Op Amp Tears

© PMI 1979

Lewis Carroll was one of our first consumer advocates. He tried, in "Alice In Wonderland," to warn his young readers about the hazards of trying new things without first finding out what they might do to you.

To prove the point, he let Alice drink from a bottle marked only "Drink Me" and bite into a cake marked "Eat Me." As a result, she grew quickly to be nine feet tall and cried such giant tears over her dilemma that she almost drowned in a pool of them when she finally came down to size again.

In Linear Wonderland, users of BIFET Op Amps have suffered a similar fate since 1975 by falling for the "Buy Me" sign on LF156A BIFETs that promised to be the "Miracle of Silicon Gulch" by obsoleting the 741. The BIFET users who fell for it have been drowning in a pool of tears so deep that even the DESC JC-41 Committee couldn't pull them out, even though they tried to by establishing a MIL-M-38510 slash sheet spec for the LF156A. The committee meetings bore a striking resemblance to Carroll's Mad Tea Party.

"Who can meet the LF156A *typical* TCV$_{OS}$ spec of 3μV/°C?" asked Alice, who only wanted a BIFET Op Amp she could really use.

"NO ONE!" shouted a chorus of March Hares from the Big Semi companies with such forcefulness that it rattled the tea cups.

"We can," said PMI, evidently too quietly for Alice to hear.

"Then how about guaranteeing the LF156A

maximum TCV$_{os}$ of 5μV/°C?" asked Alice, hopefully.

"CAN'T BE DONE!" bellowed the March Hares. "Not if you *really* want delivery of parts."

"We can guarantee it," said PMI, but a confused Alice only turned to the others and asked, "What *can* you guarantee?"

"How about 30μV/°C?", the chorus responded as Alice began crying a new pool of tears, realizing that the resulting MIL-M-38510 spec sheet proved the LF156A was not such a miracle after all.

Now PMI has taken those tears away! Just as Alice saved the little creatures from drowning in "Wonderland," PMI is now pulling engineers out of the BIFET pool with its lovable little bipolar Op Amp Model OP-01. Based on the tried and proven 741 type circuit, the OP-01 dc specs are better than the LF156A in all respects at 125°C. You'll get a lower I$_{os}$, lower I$_{B}$, lower V$_{os}$, lower TCV$_{os}$, equivalent CMRR and PSRR, higher gain and faster settling time than the LF156A. That is certainly nothing to cry about.

Even at 70°C, OP-01 specs are comparable to *available* "LF" type BIFETs, but the OP-01 has none of the long term drift problems that usually bring tears to your eyes when you're using FETs.

But the best news of all, Linear Wonderlanders, is that an OP-01 in an inverting configuration is AS FAST AS A SPEEDING LF156A!! So when you can get BIFET speed and better-than-BIFET performance, why settle for a BIFET?

Remember that by the time Alice reached the shore, her pool of tears was already crowded with curious creatures that had fallen in, such as a Dodo, a Lory and an Eaglet. If you're tired of splashing around with all those curious creatures in the BIFET pool, let PMI's OP-01 lead you ashore.

Just fill in the coupon and get your own free "NO TEARS" sample of an OP-01. Or, if you must have a BIFET, at least try a *good* one and check the OP-16 box.

If someone beat you to the coupon, write to us for your sample, or circle #200 for literature.

		Offset Voltage mV Max. −55° to +125°C	TCV$_{os}$ μV/°C Max. −55° to +125°C	Bias Current nA Max. Warmed Up @ 125°C	Slew Rate V/μS Typ @ 25°C
LF156AH (9 foot tall "Miracle of Silicon Gulch")		2.5	5.0	100	12
LF156H (Not so miraculous miracle)		7.0	–	200	12
MIL-M-38510/114-02 (Best spec that at least TWO companies would agree to)		7.0	30.0	240	12
OP-16 – (PMI's "NO TEARS" BIFET, for those who must use a BIFET)	AJ	0.9	5.0	11	12
	BJ	2.0	10.0	18	12
	CJ	4.5	15.0	25	12
OP-01 – (PMI's "Fast as a speeding BIFET" Bipolar OP/AMP)	J	1.0	8.0	50	12*
	FJ	3.0	10.0	100	12*
	GJ	6.0	20.0	200	12*

(0-70°C Grades Also Available) *Inverting Configuration only

PMI®
Precision Monolithics, Incorporated
1500 Space Park Drive
Santa Clara, California 95050
(408) 246-9222 TWX: 910-338-0528 Cable: MONO

In Europe contact:
Precision Monolithics, Incorporated
c/o Bourns Ag
ZUGERSTRASSE 74, 6340 Baar, Switzerland
Phone: 042/33 33 33 Telex: 78722

Check the box for a sample.

☐ OP-16 ☐ OP-01

Mail to:
Precision Monolithics, Inc. 1500 Space Park Drive,
Santa Clara, CA 95050
or
Precision Monolithics, Inc. c/o Bourns Ag
Zugerstrasse 74, 6340 Baar, Switzerland

My name________________________

Title________________________

Company________________________

Dept.________________________

Address________________________

____

Phone (______) ______-________

ISSCC: The conference to watch

For more than 25 years, the International Solid State Circuits Conference has been the primary forum for first details of the coming year's hot new chips. By maintaining a standard of excellence and consistently attracting top semiconductor technologists from all over the world, the conference has become much more than just another technical meeting. The program is so strong, year in and year out, that it actually points to how the basic trends are shaping up in our industry.

It is only appropriate, then, that the first ISSCC of the new decade portends a completely new direction for semiconductor technology. Whereas the 1960s saw a move from discrete devices to small-scale integration, and the 1970s from small-scale to large-scale integration, the 1980s will reflect the dramatic shift from LSI to VLSI —and with it, according to papers at this year's conference, the evolution from general-purpose to special-purpose chips.

As semiconductor makers cram more onto a tiny chip of silicon than ever before, the overall circuit function becomes more dedicated to a particular task. Now that a computer-on-a-chip has become almost commonplace, the semiconductor wizards are turning their powerful tools toward producing VLSI devices that tackle complex special-purpose functions for application areas like telecommunications, data acquisition, signal processing and consumer.

By clearly pointing to this trend, ISSCC reinforces its reputation as the leading industry indicator. Whatever the year, it is the conference to watch.

Lucinda Mattera

LUCINDA MATTERA
Editor

MEASUREMENT COMPUTATION news
product advances from Hewlett·Packard

INTERNATIONAL edition FEBRUARY 1980

A very BASIC computer to give your personal productivity a lift

HP-IB

Basically, the new HP-85 is

- a fully integrated computer (keyboard, display, CPU, magnetic tape data storage, and thermal printer) in one package small enough to fit a corner of your desk or lab bench, or to take home.
- a computer that is easy to use because of HP's BASIC language, and that requires no computer expertise.
- a computer with 16K bytes of memory (expandable to 32K bytes, able to invert a 10 × 10 matrix). It will generate graphic designs on its CRT display interactively under your control, then transform the display to hard copy on its built-in printer.
- a computer that can interface with instruments and operate as a computing controller through HP-IB and other communication protocols available later this year.
- a computer whose versatility can be enhanced with optional peripherals through HP-IB interface: a high-speed, full-width line printer, a full-sized plotter, and flexible disc drives for data storage.
- a computer with a starting repertoire of 10 application pacs, including technical, graphics, statistics, and business.

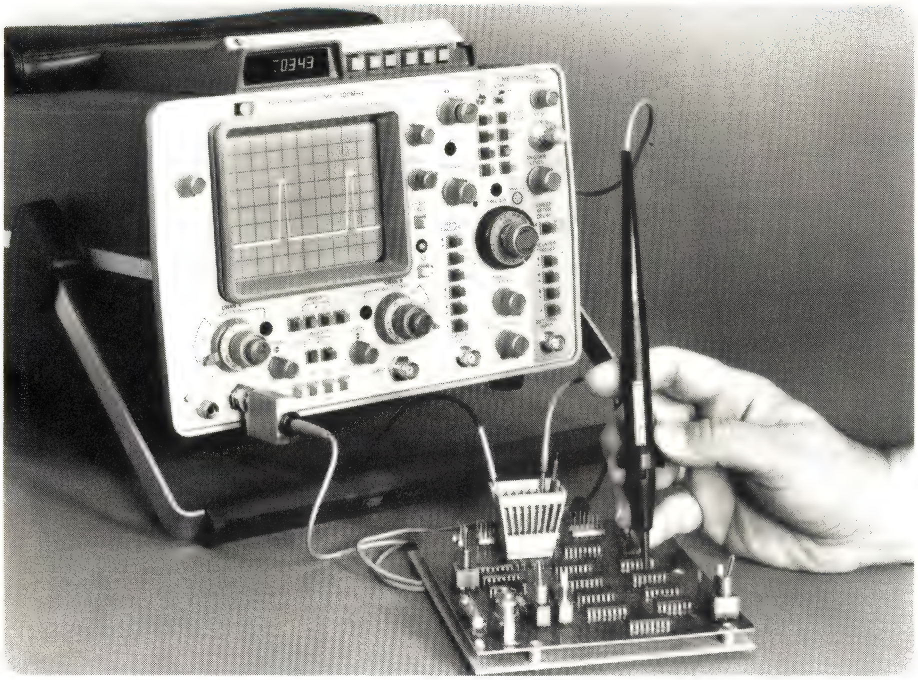
To get full information on the HP-85, check ***A*** *on the HP Reply Card.*

The HP-85 computer weighs a mere 20 pounds (9 kilograms). It's a very BASIC computer designed for individual use, with interactive graphics, expandable memory, optional peripherals, and interfacing potential disproportionate to its modest price.

IN THIS ISSUE

- First digital bar code wand
- Fast, accurate temperature probe

New temperature probe quickly, accurately locates circuit hot spots



HP's new temperature probe coupled with a 1700 series Option 034/035 oscilloscope gives you accurate temperature measurements while observing circuit operation.

HP's 10023A Temperature Probe provides the fast, accurate temperature measurements needed in a wide variety of thermal design, diagnostic and testing applications. Surface temperatures are read directly in degrees Celsius on any general purpose digital multimeter (DMM) with an input impedance of ⩾10 MΩ. Operation is simple with a convenient pencil-like probe tip and press-to-read switch. Just press the button, touch the surface to be measured, and read its temperature directly on the DMM.

The 10023A is a factory calibrated probe that does not require periodic recalibration. In fact, no internal adjustments are needed.

The calibrated linear output is 1 mV/°C, achieved by individually characterizing each diode in a precision thermal reference bath. An integrated circuit resistor network is then laser trimmed to match each diode to its electronic compensating network.

Measurement accuracy, which is traceable to the National Bureau of Standards, is ±2°C from 0°C to +100°C decreasing linearly to +2°C, −4°C at −55°C and to +4°C, −2°C at +150°C. For applications requiring relative rather than absolute measurements of similar temperatures, the probe has short-term repeatability of ±0.3°C. Fast temperature measurements are enabled by a temperature sensor with very low thermal mass positioned close to the measurement surface. This design also allows measurements with very low thermal gradient errors.

High thermal isolation reduces any tendency of the probe tip to act as a heat sink or cooling fin which may change the measured surface temperature. Minimum disturbance of the operating environment by the probe is particularly important when accurate measurements of small electronic components are needed. In addition, being electrically isolated, the probe tip can make measurements on non-grounded components such as power transistors with the collector common to the case.

The entire electronics assembly, including the battery, is packaged in the probe barrel. A standard dual banana plug output connector provides universal readout by most digital voltmeters including the built-in DMMs on HP's Option 034/035, 1700 series delta time oscilloscopes.

Check **B** *on the HP Reply Card for further information.*

HP's microprocessor lab teaches digital troubleshooting

Hewlett-Packard's 5036A Microprocessor Lab provides an aspect of microprocessor training not available in other products—microprocessor troubleshooting. What's more, it provides skill in this important area using HP's high-quality instruments and thorough documentation. The 5036A consists of a 20-lesson textbook/lab manual and a briefcase-contained operating microcomputer.

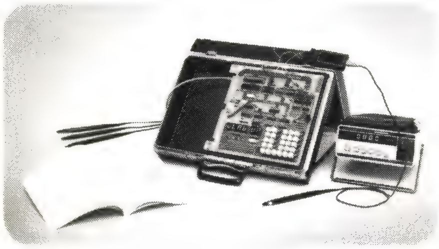
Included in the 450-page textbook are a troubleshooting tree for the lab, block diagrams, schematic, signature tables, and solutions for the lab's 12 moveable, practice fault jumpers. In short, all documentation needed to completely troubleshoot the lab.

Troubleshooting Lessons Build Skill on Microprocessors

The lab's textbook, "Practical Microprocessors" culminates in four highly practical troubleshooting lessons:

- **Handheld Troubleshooting Tools:** Hands-on troubleshooting using HP's 5024A IC Troubleshooters Kit: the 545A Logic Probe, 546A Pulser, and 547A Current Tracer.
- **Signature and Logic Analyzers:** Introduction to HP's 5004A Signature Analyzer and HP's Logic Analyzers.
- **Troubleshooting μP Systems:** Troubleshooting theories and useful tips.
- **Troubleshooting the Microprocessor Lab:** Detailed troubleshooting experiments on the lab using signature analysis.

For details on HP's integrated system for learning microprocessors, check **C** *on the HP Reply Card.*



The 5036A Microprocessor Lab with optional 5004 Signature Analyzer and 5024A IC Troubleshooters Kit provide actual hands-on microprocessor troubleshooting experience.

HEWLETT-PACKARD COMPONENT NEWS

New Digital Bar Code Wand's 0.3 mm resolution enhances bar code readability

Hewlett-Packard's new HEDS-3000 Digital Bar Code Wand greatly enhances the readability of dot matrix printed bar codes thanks to its 0.3 mm (0.012 in.) resolution.

The world's first digital bar code wand, this handheld scanner is an effective alternative to the keyboard when used to collect information in self-contained blocks. In addition to the convenience advantages, bar code scanning is also faster than key entry and more accurate since most codes have check sums built-in to prevent incorrect readings from being entered.

Equipped with an integral push-to-read switch, the HEDS-3000 consumes power only when the switch is depressed. It is well suited to portable systems as well as those with line power. Housed in a rugged, stylized, molded plastic case with attached cord and connector, the wand can be manufactured in custom colors with desired logos.

Applications include remote data collection, ticket identification systems, security checkpoint verification, file folder tracking, inventory control, identifying assemblies in service, repair and manufacturing environments as well as programming of appliances, intelligent instruments and personal computers.

This new HEDS-3000 Digital Bart Code Wand is designed to scan black-and-white bar code and output TTL and CMOS-compatible signals. The heart of the wand is an advanced, high-resolution, high-speed, emitter/detector sensor in a sealed module near the removable tip.

Check **D** *on the HP Reply Card for details.*

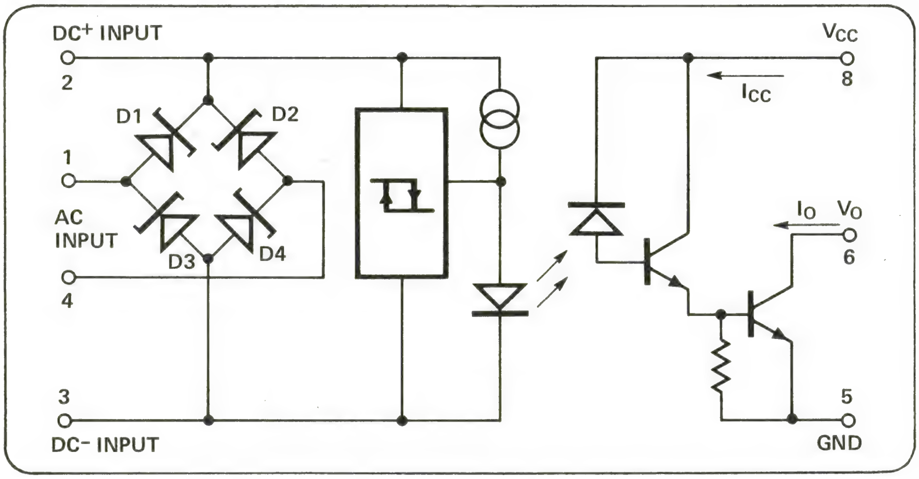
New AC/DC threshold sensing optocoupler

A new voltage/current threshold detection optocoupler with guaranteed input-threshold specifications and logic-compatible output is now available from HP. It is designed for industrial control computer input boards and other applications where a predetermined input threshold level is desirable.

The HCPL-3700 combines a threshold-sensing input buffer IC, an internal LED, and a high-gain photon detector to provide an optocoupler which features adjustable external threshold levels and logic-compatible output.

The input buffer IC contains a reference voltage circuit and a comparator that compares the input signal with the reference voltage. When the "threshold" is reached the comparator switches and turns on current to the LED. The nominal turn-on threshold is 2.5 mA and 3.8 V, but the addition of one or more external attenuation resistors permits the user to set the threshold switching point of the HCPL-3700 over a wide range of input voltages and currents. Additionally, a hysteresis circuit in the comparator minimizes false LED turn-on for electrically noisy input signals.

Obtain all details by checking **E** *on the HP Reply Card.*



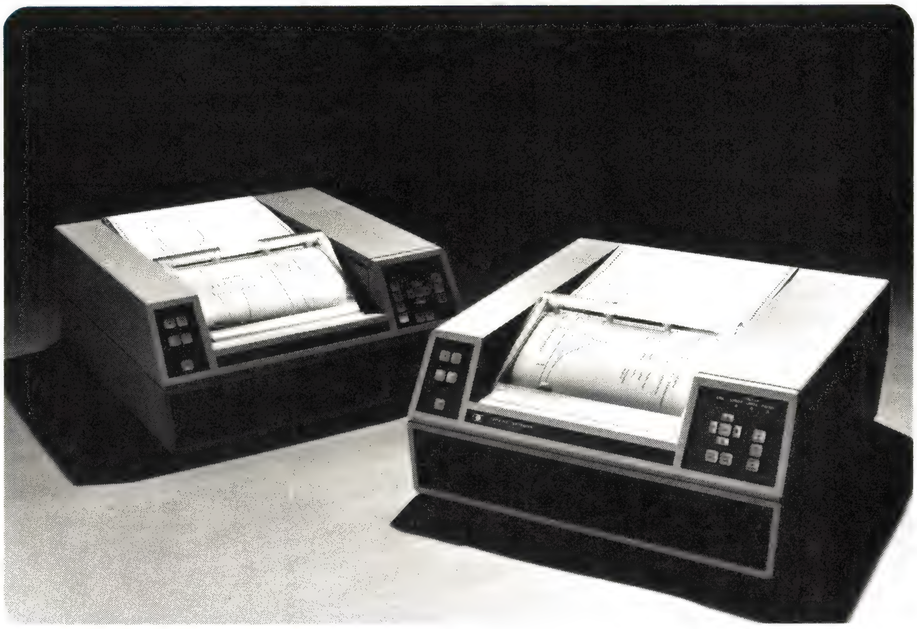
Printer/plotter delivers high-quality graphics and an impressive range of capabilities

HP-IB

If your application calls for high quality graphics, a combination of vector plotting with extensive annotation, unattended operation, or long axis plotting, HP has a plotter/printer for your needs and your interface requirement. The Models 7245B and 7240A are HP-IB and RS-232-C versions of the same plotter/printer. They combine a state-of-the-art, thermal printhead and a newly developed Hewlett-Packard soft writing surface to provide high quality vector graphics and printing.

With a printing speed of 38 characters-per-second (CPS) and plotting speeds equal to or greater than that of many dedicated vector plotters, these HP desktop plotter/printers are outstanding general purpose devices. The Model 7245B HP-IB plotter/printer is an excellent companion for your desktop computer or computer system while the 7240A RS-232-C plotter/printer can be used either via telephone modem for remote applications or hardwired to your computer.

Some areas of application are engineering design, production testing, data acquisition, process monitoring, analytical plotting, long-term business forecasting, business reports, long-axis survey plotting, and project management.



Both models are microprocessor-based and use a bidirectional paper drive to advance a 61-metre (200 foot) roll of thermosensitive paper for unattended plotting and bidirectional long-axis plotting up to 5 metres (16.4 feet). A patented microstep sprocket paper drive gives them excellent line quality, and repeatability of 0.25 millimetres (0.010 inches) maximum from any point on the chart.

Blue printing and black printing thermosensitive paper is available for both units.

For full details, check **F** *on the HP Reply Card.*

MEASUREMENT COMPUTATION news
product advances from Hewlett-Packard

Europe-Central Mailing Dept., P.O. Box 529,
Amstelveen-1134, Netherlands,
Ph.(020) 47 20 21.
Japan-Yokogawa-Hewlett-Packard Ltd.,
29-21 Takaido-Higashi 3-chome
Suginami-ku, Tokyo 168, Ph. 03-331-6111.
Elsewhere outside the U.S.A.-1507 Page Mill Rd.,
Palo Alto, California, 94304, U.S.A.

January/February 1980

New product information from
HEWLETT-PACKARD

Editor:
Bojana Fazarinc

Editorial Offices:
1507 Page Mill Road
Palo Alto, California, 94304 U.S.A.

HEWLETT PACKARD

Everything you need to know about flat cable/ connector systems.

To save space. To increase circuit flexibility and reliability. To lower total installed cost. To profit from the state-of-the-art in mass termination.

T&B/Ansley offers you the industry's broadest line of flat cable/connector systems. That's because we've been flat cable specialists for decades, and we were pioneers in the development of cost effective mass-termination techniques for volume production and ease of assembly.

Now we're also offering an engineering specification bible that tells you everything you need to know about mass-termination cable/connector systems.

That includes connectors, headers, mounting hardware. It includes round and flat conductor flat cable, as well as jacketed and shielded jacketed cable. It includes our MICRO-PITCH line, which is ideal for mass termination in high density, controlled impedance applications. And our FLEXSTRIP® Jumpers, the most flexible, reliable components available for interconnecting one circuit board to another.

It includes a complete line of hand and bench tools for volume installations, small production runs, or field service applications.

And a great deal more. And it's free. So you'll never get a better offer. Call or write today.

T&B/Ansley

The mass termination company.

T&B/Ansley Corporation
Subsidiary of Thomas & Betts Corporation
3208 Humboldt St. • Los Angeles, CA 90031
Tel. (213) 223-2331 • TELEX 68-6109
TWX 910-321-3938

Stocked and Sold through Authorized Ansley Distributors.

CIRCLE NUMBER 26

Send for your free copy today!

International T&B/Ansley Offices: AUSTRALIA, Brookvale, (02) 938-1713 • **AUSTRIA,** Vienna, (222) 645206 • **CANADA,** Iberville, Quebec, (514) 347-1014 • **ENGLAND,** Luton, (0582) 597-271 • **FRANCE,** Rungis, 687-23-85 • **HOLLAND,** Zoetermeer, (79) 214688 • **ITALY,** Milano, 02-4986451 • **JAPAN,** Tokyo, 03-354-9661 • **SINGAPORE** (65) 2923711 • **SOUTH AFRICA,** Benrose 24-8134 • **SPAIN,** Barcelona, (93) 212-8607 • **SWEDEN,** Upplands Vasby, 0760-86140 • **SWITZERLAND,** Hombrechtikon, (04155) 422791 • **WEST GERMANY,** Dreieich bei Frankfurt, 06103-8 20 21.

For film capacitors in volume . . .

talk to the reel people.

SPRAGUE TYPE 192P

Plastic-sleeved
PACER® Capacitors

Polyester film. Unique construction . . . extended foil sections terminated in metal end caps to which leads are attached . . . outer protection is tough plastic sleeve. Capacitance values from .0001 to .39μF. Voltage ratings from 80 to 600 WVDC.

Write for Bulletin 2066C
or circle number 27

SPRAGUE TYPE 413P

Epoxy-coated
FILMITE® 'E' Capacitors

Polyester film. Conformal epoxy coating and excellent lead concentricity permit automatic insertion. Preferred where size and cost are important. Capacitance values from .001 to .1 μF. Voltage ratings of both 100 and 200 WVDC.

Write for Bulletin 2061B
or circle number 28

SPRAGUE TYPE 416P

Film-wrapped
YELLOW JACKET® Capacitors

Polyester film. Extended foil sections protected against moisture by outer wrap of polyester or polyolefin film. Plastic resin end seals. This construction results in weight/space advantages. Capacitance values from .001 to 1μF. Voltage ratings, 50 to 600 WVDC.

Write for Bulletin 2063C
or circle number 29

SPRAGUE TYPE 433P

Epoxy-coated
METFILM® 'E' Capacitors

Closely-controlled metallized polyester film. Superior conformal epoxy coating. Low cost for use in entertainment electronics, yet dependable enough for industrial applications. Capacitance values from .027 to 1.0μF. Voltage ratings from 100 to 400 WVDC.

Write for Bulletin 2060A
or circle number 30

4SP-8144R2

For complete technical data on the capacitor type(s) in which you are interested, write for appropriate engineering bulletin(s) as shown above, to: Technical Literature Service, Sprague Electric Co., 347, Marshall St., North Adams, Mass. 01247.

SPRAGUE®
THE MARK OF RELIABILITY

THE BROAD-LINE PRODUCER OF ELECTRONIC PARTS

a subsidiary of **GK Technologies** Incorporated

U.S. electronics supports Russian embargo—if. . .

President Carter's decision to restrict exports of high-technology products like computers and similar electronic devices to the Soviet Union has won conditional support from the U.S. electronics industry, despite the sales loss the embargo will cause.

The Electronic Industries Association Board of Governors has called on the President to enlist cooperation from other industrialized nations in the boycott. "The moratorium can only be effective if a concerted effort is taken by the Administration to get the support of our allies to deny Russia high-technology products," says EIA President Peter F. McCloskey.

A spokesman for a Maryland electronics firm calls the embargo a "good move" so long as other countries go along. "We aren't the only ones who have sophisticated electronics to sell," he says. "If Japan and the European countries don't follow us, they'll just increase their sales to make up the difference and grab a bigger share of an international market that's highly competitive."

Meanwhile, it is still unclear just what products will be covered by the moratorium. White House officials say all export licenses to the Soviet Union are being reviewed. The wording of the embargo message leaves open questions about whether it will apply only to new orders for equipment or will kill export deals already negotiated and awaiting shipment.

U.S. is losing technological edge: economic committee

As if to underscore the point that the U.S. cannot impose a cutoff of technology to the Soviets by itself, a business and academic group called the Committee for Economic Development has issued a report stating that the nation is losing its technological edge, a development contributing to inflation, low productivity, trade deficits and other economic problems.

"Without technological progress," the report says, "industry creates few jobs, factories and equipment become obsolete, productivity stagnates and inflation becomes more difficult to control. If industry cannot produce goods and services more efficiently, it becomes less competitive in international markets and cannot compensate for rising costs except by raising prices."

The report recommends a streamlining of patent-registration procedures and other government regulations along with changes in tax laws, including a more rapid capital-recovery allowance than the current depreciation allowances.

Comsat to get Congressional scrutiny

Evidently, going public does not keep the Congressional watchdogs away. The House Subcommittee on Communications will conduct a series of hearings in March centering on the Communications Satellite Corporation (Comsat) and its U.S. subsidiary, Comsat General.

Although the corporation is now an independent, publicly held company, it was created in 1962 by an act of Congress to represent the U.S. in Intelsat, the global communications satellite organization. This early Congressional involvement makes the probe both appropriate and necessary, according to the subcommittee. The hearings will focus on several issues:

- Comsat's role in Inmarsat, the international maritime satellite organization, and its current dominant position as U.S. representative and systems manager for Intelsat
- Comsat General's participation in the Comstar system with AT&T, and its partnership with Aetna Life and IBM in the Satellite Business Systems (SBS)

business network that was formed in 1975.

- Comsat General's manufacturing and selling of satellite terminal equipment, and its plans for a direct satellite-to-home entertainment broadcasting system.

The committee's questioning of company officials on the partnership with Aetna and IBM and the home broadcast system is expected to be particularly intense. The arrangement has drawn attention from the Justice Department, which recently asked the FCC to take a closer look at its approval of the SBS plans. The satellite broadcast project, which will be put before the FCC in March, has been criticized by conventional broadcasters as well as by operators of cable television systems.

Quartz-crystal makers oppose duty-free designation

U.S. producers of quartz crystals have filed a petition with the Office of the Special Trade Representative opposing plans to classify the industry as duty-free under trade laws. The classification would permit the lifting of import tariffs on crystals brought into the U.S. from other producing nations.

Two primary foreign producers, Argentina and Singapore, recently asked the U.S. to lift the tariffs. A similar request was denied in 1978. U.S. producers maintain that conditions in the industry have not changed enough to warrant a switch in policy. In fact, the manufacturers say that from 1977 to 1979, during which the domestic industry had been severely depressed, import penetration of the U.S. market for piezoelectric crystals increased from 5% to 9.3%.

Further reductions in tariffs would cripple an industry that already operates at 25% to 30% of capacity, the petition argues. President Carter is expected to resolve the issue by early April.

Good news: Aerospace industry expected to grow

Aerospace-industry sales in 1980 could top $68.9-billion, a solid increase over the 1979 figure of $55.2-billion, predicts the Commerce Department. If this prediction proves correct, there could be a similar period of growth for the segment of the electronics industry tied to aerospace production.

This optimistic outlook stems primarily from a steady increase in orders of large commercial transport aircraft, a situation that's just the reverse of conditions several years ago, when sales of military aircraft dominated the market.

Another bright spot is the projected growth in exports—to $15.3-billion in 1980. A strong segment of the aerospace economy is involved in this sector, say the analysts, noting that 45% of all aerospace jobs are connected to exported products. In addition, imports are likely to reach about $2.1-billion, demonstrating the competitive lead that the U.S. aerospace manufacturers still command over their foreign counterparts.

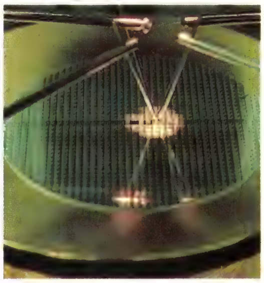
Small business petitions for—and gets—White House attention

Four days of discussions preceded by more than two years of planning has produced 15 high-priority recommendations for President Carter and Congress from the White House Conference on Small Business, and promises from both the White House and Congress that the proposals would get prompt attention from government officicals.

Recommendations include detailed proposals for spurring investment in small businesses (those with 500 or fewer employees), tax breaks for small-business operators and guaranteed participation in federal procurement.

In announcing their proposals, delegates to the conference reminded government officials that the 10.4-million firms they represent contribute 43% of the U.S. gross national product and provide more than half its jobs.

No compromise solutions.

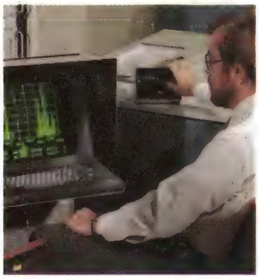


The Tektronix S-3280 is the first test system specifically designed to test ECL, LSI devices. Every S-3280 has high-speed drivers, giving you a pulse source for every channel. Precision fixturing allows you to connect the device to the tester with minimum signal distortion. And there are up to 64 channels of sampling for waveform analysis, ensuring high fidelity.

Flexibility.

Multiple pattern sources give you an effective, flexible means of implementing complex patterns. Choose the method of pattern generation that fits the device under test.

Compatibility.



Only one language to learn. All Tektronix S-3200 systems use TEKTEST, a test-oriented language very close to English. Your test engineers will quickly generate, edit, and debug device-testing programs.

Proven performance.

Semiconductor test systems are nothing new to Tektronix, we've been building them for years. In addition to the S-3280 ECL, LSI tester, there's the S-3270 for device characterization, and the S-3250 for production testing. Each has a 20 MHz clock rate. Our wide variety of options allows you to buy what you need now, and add to it anytime.

Training.

We'll support your test engineers with a comprehensive training program and thorough documentation.

Worldwide support.

We're a phone call away.

To find out which S-3200 system and its options best meet your needs, call your local Tektronix representative.

Tektronix®
COMMITTED TO EXCELLENCE

Another first from Tektronix. The high-speed solution for subnanosecond logic testing.

High-speed drivers.

Precision 50 ohm fixturing.

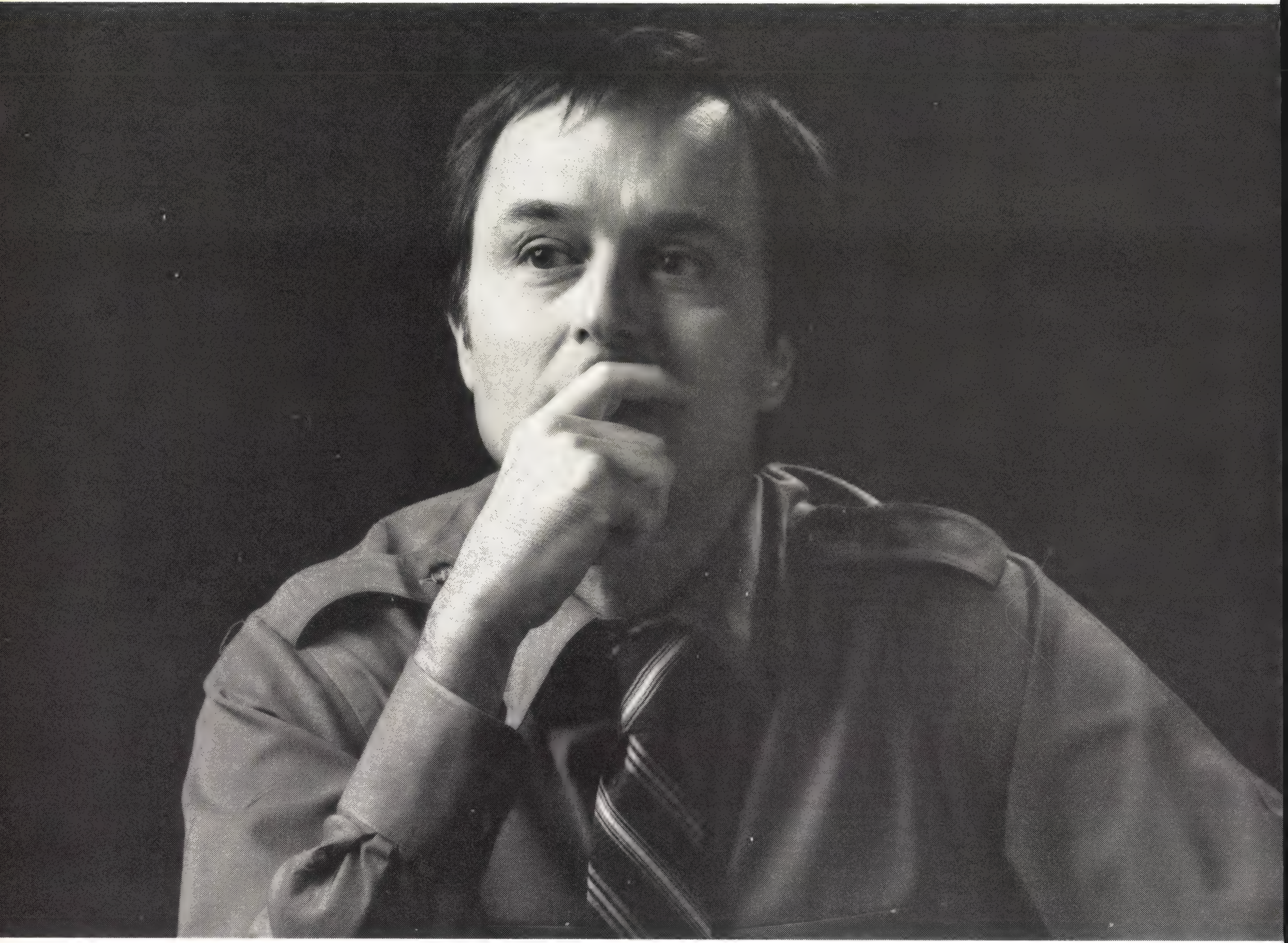
Waveform analysis.

We make moving ahead easy.

S-3280

Copyright © 1979, Tektronix, Inc. All rights reserved. 848

"WHAT THIS COUNTRY HIGH SPEED, SUPER-



YOU GOT IT.

It's called the IM7147. And Intersil makes it. It's a low-power, 4K static RAM with 55ns access times.

	Operating Power	Standby Power	Access Time
IM7147	125mA	20mA	70ns
IM7147L	100mA	10mA	70ns
IM7147-3	**125mA**	**30mA**	**55ns**
IM7147L-3	**110mA**	**20mA**	**55ns**
(military) IM7147LM	125mA	20mA	85ns

Now, you're probably thinking you'll have to pay an arm and a leg for that combination of performance. Not so. Intersil 4K statics are super competitive with anything even near to equivalent in the market today.

SAVE BIG BUCKS.

Sure, you'll save when you buy from Intersil. But, you're going to see even greater savings when you start designing the 7147 into new systems. It's great for high-speed, large memory applications. Because it runs on a smaller power supply and it needs only a fraction of the cooling other RAMs require. Lower power dissipation also means greater reliability for the entire system.

NEEDS IS A LOW-POWER 2147.”

A FAMILY THAT WON’T QUIT.

Don’t get us wrong. We have the high-performance 4Ks, but we also have a raft of the regular 4Ks. So, if you need standard 2147s for existing sockets, we’ve got you covered. Same with 2114s and 7141s (2141s).

Any way you slice it — 1K x 4 or 4K x 1, low-power or industry standard, commercial or military — Intersil’s got your part. At a competitive price. And we’re quoting immediate delivery. Off the shelf. It you don’t believe it, just try us with an order.

COMING ATTRACTIONS.

Sounds like we have our act together, right? Well, we’re not stopping there.

To give just a peek at the future, in first quarter 1980, we’ll be bringing out the IM7148. It’s a new high-performance, low-power 4K especially well-suited to mainframe memories.

FROM THE LOW-POWER WHIZ KIDS.

Actually, it shouldn’t surprise you that Intersil is doing all this. Since we’re known for our innovation in CMOS technology. But it hasn’t been by accident. We’ve focused on it. Because one of the things we thought this country needed was a good low-power technology company.

INTERSIL NMOS STATIC RAM FAMILY		Operating Power	Access Time
1K x 4	IM2114-2 (D2114-2)	100mA	200ns
	IM2114-3 (D2114-3)	100mA	300ns
	IM2114 (D2114)	100mA	450ns
	IM2114L2 (D2114L2)	70mA	200ns
	IM2114L3 (D2114L3)	70mA	300ns
	IM2114L (D2114L)	70mA	450ns
	IM7114L2	50mA	200ns
	IM7114L3	50mA	300ns
	IM7114L	50mA	450ns
4K x 1	IM7141-2	70mA	200ns
	IM7141-3	70mA	300ns
	IM7141	70mA	450ns
	IM7141L2	50mA	200ns
	IM7141L3	50mA	300ns
	IM7141L	50mA	450ns
4K x 1	D2147	160mA	70ns
	D2147L	140mA	70ns
	D2147-3	180mA	55ns
	IM7147	125mA	70ns
	IM7147L	100mA	70ns
	IM7147-3	125mA	55ns
	IM7147L-3	110mA	55ns
	MD2147	180mA	85ns
	IM7147LM	125mA	85ns

Military temperature available in all devices.

INTERSIL SALES OFFICES:

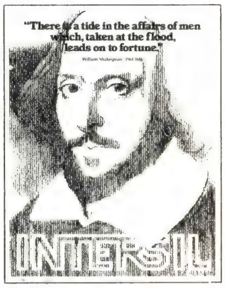
CALIFORNIA: Sunnyvale (408) 744-0618, Long Beach (213) 436-9261 • COLORADO: Aurora (303) 750-7004 • FLORIDA: Fort Lauderdale (305) 772-4122 • ILLINOIS: Hinsdale (312) 986-5303 • MASSACHUSETTS: Lexington (617) 861-6220 • MINNESOTA: Minneapolis (612) 925-1844 • NEW JERSEY: Englewood Cliffs (201) 567-5585 • OHIO: Dayton (513) 866-7328 • TEXAS: Dallas (214) 387-0539 • CANADA: Brampton, Ontario (416) 457-1014

INTERSIL FRANCHISED DISTRIBUTORS:

Advent (IND, IA) • Alliance • Arrow • Bell Industries • CESCO • Component Specialties • Components Plus • Diplomat (FLA, MD, NJ) • Harvey (upstate NY) • Intermark • Kierulff • LCOMP • Parrott • R.A.E. Ind. Elect. Ltd. • RESCO/Raleigh • Schweber • Summit • Wyle • Zentronics Ltd.

INTERSIL

DIGITAL PRODUCTS — MEMORY
10710 No. Tantau Ave., Cupertino,
CA 95014
Tel: (408) 996-5000 TWX: 910-338-0171
(800) 538-7930 (outside California)


“There is a tide in the affairs of men which, taken at the flood, leads on to fortune.”
William Shakespeare 1564-1616
INTERSIL

Wow! Am I ever interested in your 4K static RAMS.

______Please send me information on your RAM line.

______And include your 20 x 24″ Shakespeare poster. I like that idea, too.

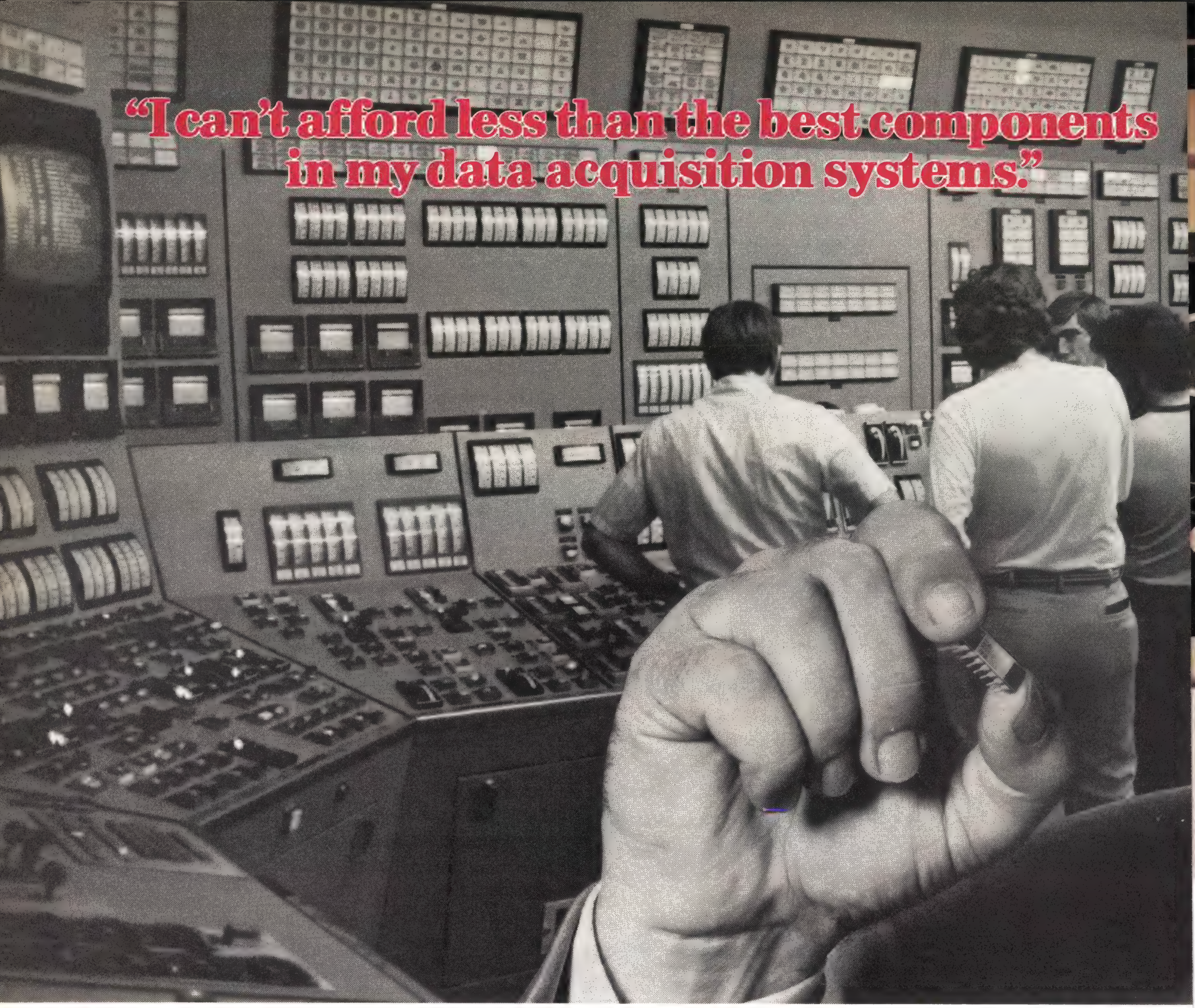
Name ______________________

Company ______________________

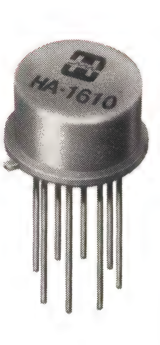
Address ______________________

City/State/Zip ______________________

ED21580


"I can't afford less than the best components in my data acquisition systems."

Now! Harris introduces Precision Voltage References as good as your systems!



Now, Harris Semiconductor gives you a new family of monolithic voltage references that meet the precision and accuracy requirements of today's high resolution data systems—over temperature, over time, over load.

The Harris HA-1600, HA-1610, HA-1615 and HA-1620 are laser-trimmed for precise output voltages within a few millivolts of nominal value. All devices feature outputs buffered by an op amp with an uncommitted feedback loop for current drive flexibility and stability under load.

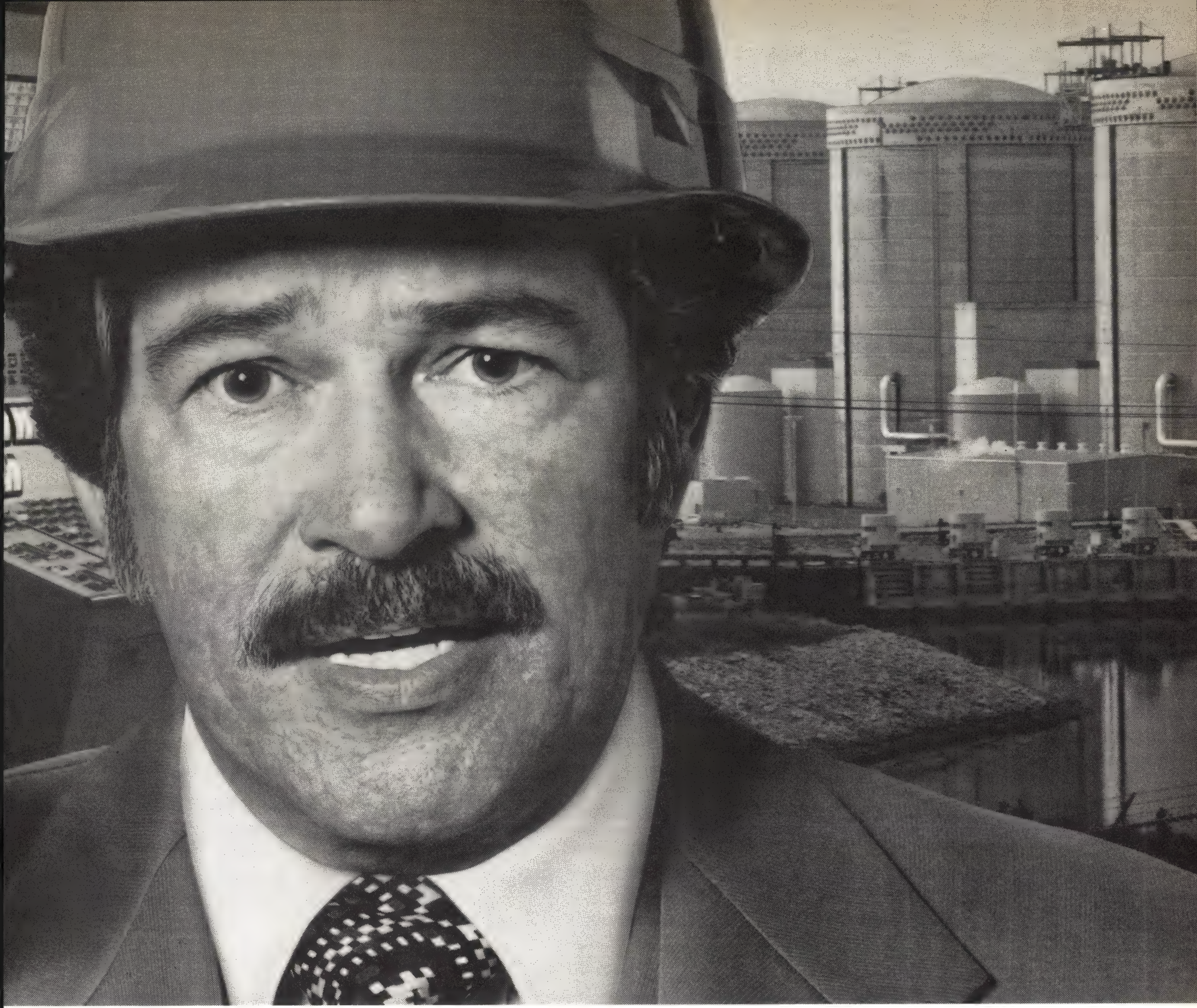
The HA-1600, HA-1610 and HA-1615 are +10 V output devices. The HA-1620 is a +5 V reference with the additional feature that the output can be adjusted ±0.5 V.

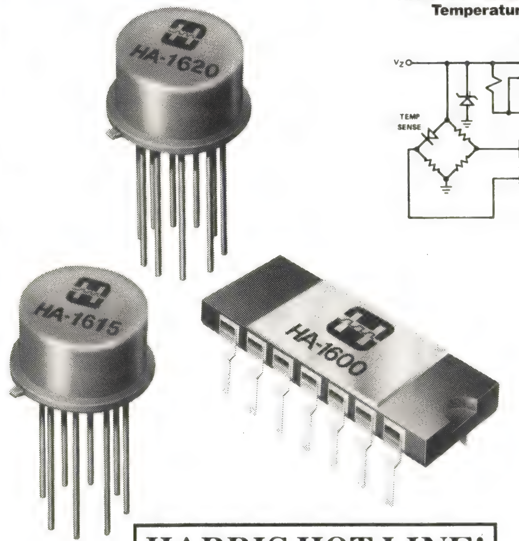
Accuracies of this line of references go to ±1 LSB over full military temperature range for 12-bit systems.

Here's the important bottom line—now you can get a reference that is as good as your system, with accuracies to better than 1 LSB!

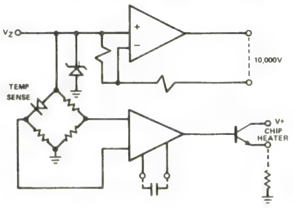
Put a new level of accuracy into your data acquisition system. Specify Harris voltage references. Prices range from $5.00 for the commercial version of the HA-1615, to $30.00 for the military version of the HA-1600 (100-999 quantities). Availability from stock.

Call the Harris Hot Line, or write: **Harris Semiconductor Products Division, Box 883, Melbourne, Florida 32901.**

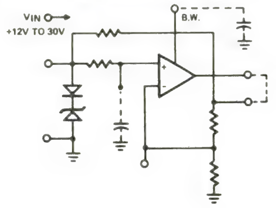




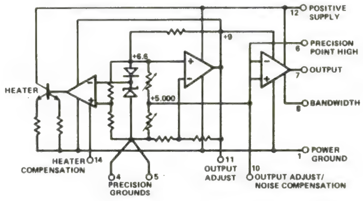
HA-1600 Precision 10 Volt Reference Temperature Regulated Chip



HA-1610/HA-1615 10 Volt Precision Reference



HA-1620 Precision 5 Volt Reference With Adjustable Output



Harris Precision Voltage References Performance Parameters

Harris Part No.	Output Voltage	Temperature Range	Package	Tempco, Max. (ppm/°C)	Line Reg., Max. (%/V)	Load Reg., Max. (%/mA)	Resolution for 1 LSB Accuracy
HA1-1600-2	+10	−55 to +125°C	14-Pin Hermetic Dip	1.35	0.002	0.002	12 Bits
HA1-1602-2	+10	−55 to +125°C	14-Pin Hermetic Dip	2.70	0.002	0.002	11 Bits
HA1-1605-5	+10	0 to +75°C	14-Pin Hermetic Dip	3.25	0.002	0.004	12 Bits
HA2-1610-2	+10	−55 to +125°C	TO-99 Metal Can	3.0	0.004	0.004	10 Bits
HA2-1610-5	+10	0 to +75°C	TO-99 Metal Can	3.0	0.004	0.004	12 Bits
HA2-1615-2	+10	−55 to +125°C	TO-99 Metal Can	5.0	0.004	0.004	9 Bits
HA2-1615-5	+10	0 to +75°C	TO-99 Metal Can	5.0	0.004	0.004	11 Bits
HA2-1620-2	+5	−55 to +125°C	TO-100 Metal Can	1.0	0.002	0.002	12 Bits
HA2-1620-5	+5	0 to +75°C	TO-100 Metal Can	1.0	0.002	0.002	13 Bits

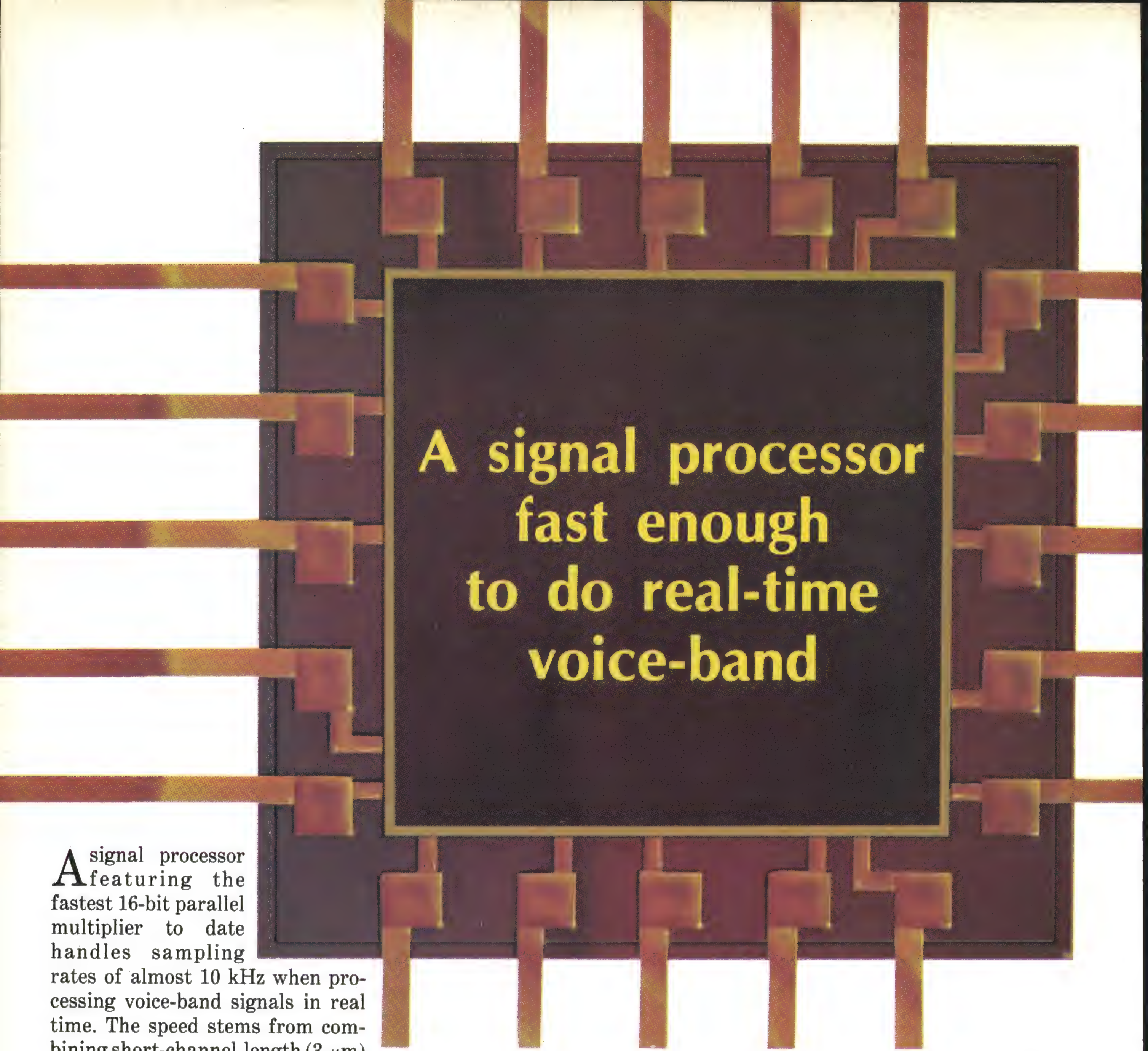
HARRIS HOT LINE!
1-800-528-6050, Ext. 455
In Arizona: 1-800-352-0458, Ext. 455

Call toll-free (except Hawaii & Alaska) for phone number of your nearby Harris sales office, authorized distributor or expedited literature service. Or check your IC MASTER for complete product listing and specifications.

Harris Technology ...Your Competitive Edge

HARRIS
SEMICONDUCTOR PRODUCTS DIVISION
A DIVISION OF HARRIS CORPORATION

CIRCLE NUMBER 31



A signal processor fast enough to do real-time voice-band

A signal processor featuring the fastest 16-bit parallel multiplier to date handles sampling rates of almost 10 kHz when processing voice-band signals in real time. The speed stems from combining short-channel-length (3-μm) NMOS technology with a special architecture.

The chip can either process analog signals or perform the analog-I/O function for another main processor in voice-band signal-processing applications requiring real-time speeds. These include digital filters, Fast Fourier transforms, modems, adaptive differential PCMs, voice recognizers and synthesizers.

Here, the μPD7720 from NEC stands well apart from conventional NMOS processors. Any voice-band signal-processing application requires extremely complex real-time processing of large numbers between predetermined sampling intervals. This could involve several sections of multiple-order digital filters. For every second-order filter section, for example, the processor must perform four multiplications, four additions and two moves. But conventional NMOS processors could not perform 8 or 16-bit manipulations fast enough to allow for even two or three sections of filtering within an 8-kHz sampling rate (125 μs).

The NEC μPD7720, on the other hand, can process 16-bit data fast enough to allow the implementation of 55 second-order filter sections while maintaining an 8-kHz sampling rate. Having an architecture aimed at voice-band applications helps. It includes:

- A 16-bit high-speed parallel multiplier
- A 23-bit single-word microinstruction
- A split internal bus structure
- Serial I/O ports and parallel bus interface
- Two accumulators
- A separate coefficient (data) ROM.

The chip's major functional blocks consist of the multiplier, memory, I/O, ALU and timing control logic (Fig. 1).

Blessed with its own I/O registers, the 16-bit multi-

David F. Millet, Product Marketing Manager, Microprocessors, NEC Microcomputers Inc., 173 Worcester St., Wellesley, MA 02181.

plier is separate from the ALU and functions independently. The multiplier, which uses Booth's algorithm, is constructed via 143 full adders, which occupy 3 mm^2 of chip area.

Full parallel multiplication takes 250 ns. The multiplier operates on two, 16-bit two's-complement numbers in the K and L registers, and yields a 31-bit result in the M and N registers. The high-order 15 bits and the sign are in the M register, and the lower-order 15 bits are in the N register. The timing of the multiplication is such that the result is available as a source for the next ALU operation, if specified.

The memory is divided into three sections: instruction ROM, coefficient ROM and data or scratchpad RAM. The instruction ROM is 512 words × 23 bits. The 23-bit-wide word allows all instructions to be single words, which eliminates the need for multiple-instruction fetch cycles. As a result, all instructions can be fetched and executed in one 250-μs cycle.

Along with the instruction ROM, a small RAM register functions as a four-level stack and program counter.

Tables provided

The coefficient or data ROM (512-word bits × 13) works separately from the instruction ROM as an input to the multiplier, and provides data tables for other calculations. The 13-bit data can be extended to 16 bits for internal calculations by adding three zeroes in the LSB positions. This information can be called upon simultaneously by any instruction as an input to the multiplier or as a source register for operations. As a result, instructions can use immediate data not included in the instruction itself but located in the separate data ROM.

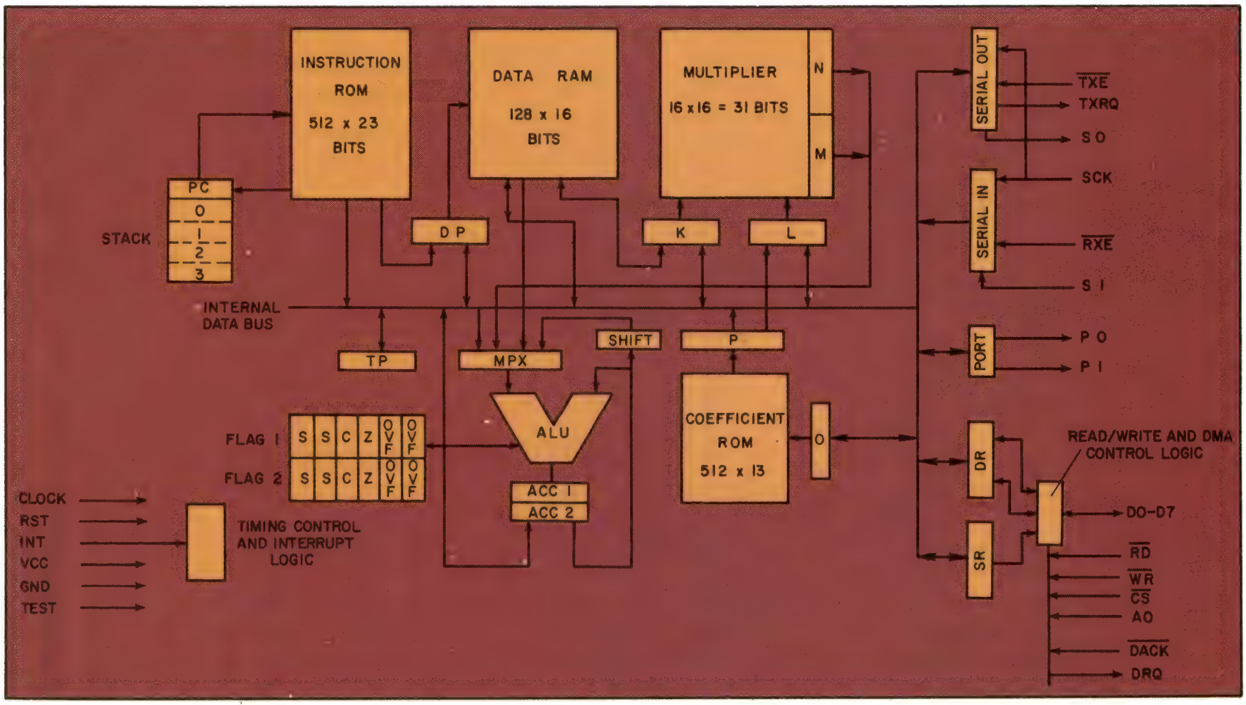
Variable data storage is the province of the 128-word × 16-bit data RAM. It stores I/O information, intermediate results and other variables in the complex calculations required for real-time signal processing.

Dual data path

The data RAM can be designated as a source or destination register for any instruction, but not both. A separate data path provides for direct input to the multiplier. This eliminates bus conflicts when two variables are required by the multiplier. This dual data path is provided between other sections of the signal processor to prevent bus conflicts during the execution of complex instructions.

The main internal data bus has access to all blocks: data RAM, instruction ROM, RAM, multiplier and I/O interface. However, many instructions require two source locations simultaneously. To avoid unnecessary data moves before an instruction is executed, most operands are available to the multiplier and ALU by auxiliary data paths to the common-source locations. This eliminates many of the move instructions typical of other architectures.

The basic I/O structure is divided into two sections: serial for the analog-to-digital interface, and parallel for the processor interface. The two serial interfaces share a common clock and a simple handshake to limit the number of pins dedicated to what is only a 100 to 200-kbit/s interface. This allows the signal processor to be packaged in a 28-pin package and still be easily interfaced to available ADCs and DACs.



1. Because many instructions require access to two source locations simultaneously, most operands are available to the multiplier and ALU through auxiliary data paths, thus reducing the number of fetch/execute events.

Instruction tables

AL_0	AL_1	AL_2	AL_3	ALU functions
0	0	0	0	No operation
0	0	0	1	OR
0	0	1	0	AND
0	0	1	1	EXCLUSIVE-OR
0	1	0	0	Subtract
0	1	0	1	Add
0	1	1	0	Subtract with borrow
0	1	1	1	Add with carry
1	0	0	0	A_{CC} decrement
1	0	0	1	A_{CC} increment
1	0	1	0	Complement A_{CC}
1	0	1	1	1-bit shift right
1	1	0	0	1-bit shift left
1	1	0	1	2-bit shift left
1	1	1	0	4-bit shift left
1	1	1	1	8-bit exchange

s_0	s_1	s_2	s_3	Specified registers
0	0	0	0	No register
0	0	0	1	$A_{CC}1$
0	0	1	0	$A_{CC}2$
0	0	1	1	Temporary
0	1	0	0	Data pointer
0	1	0	1	O register
0	1	1	0	P register
0	1	1	1	No register
1	0	0	0	Status register
1	0	0	1	DR (DRQ set)
1	0	1	0	DR (DRQ not set)
1	0	1	1	SI ($SI_0 - SI_{15}$)
1	1	0	0	SI ($SI_{15} - SI_0$)
1	1	0	1	K register
1	1	1	0	L register
1	1	1	1	Memory (addressed by the contents of DP)

d_0	d_1	d_2	d_3	Specified registers
0	0	0	0	No register
0	0	0	1	$A_{cc}1$
0	0	1	0	$A_{cc}2$
0	0	1	1	Temporary
0	1	0	0	Data pointer
0	1	0	1	O register
0	1	1	0	Data register
0	1	1	1	Status register
1	0	0	0	Serial out
1	0	0	1	Serial out
1	0	1	0	K register
1	0	1	1	DATA BUS → K P → L
1	1	0	0	DATA RAM → K DATA bus → L
1	1	0	1	L register
1	1	1	0	No register
1	1	1	1	Memory (addressed by the contents of DP)

C_0	C_1	C_2	C_3	C_4	Condition
0	0	0	0	0	$C_1 = 0$
0	0	0	0	1	$C_1 = 1$
0	0	0	1	0	$C_2 = 0$
0	0	0	1	1	$C_2 = 1$
0	0	1	0	0	$Z_1 = 0$
0	0	1	0	1	$Z_1 = 1$
0	0	1	1	0	$Z_2 = 0$
0	0	1	1	1	$Z_2 = 1$
0	1	0	0	0	$OVF_1 = 0$
0	1	0	0	1	$OVF_1 = 1$
0	1	0	1	0	$OVF_2 = 0$
0	1	0	1	1	$OVF_2 = 1$
0	1	1	0	0	$OVF'_1 = 0$
0	1	1	0	1	$OVF'_1 = 1$
0	1	1	1	0	$OVF'_2 = 0$
0	1	1	1	1	$OVF'_2 = 1$
1	0	0	0	0	$S_1 = 0$
1	0	0	0	1	$S_1 = 1$
1	0	0	1	0	$S_2 = 0$
1	0	0	1	1	$S_0 = 1$
1	0	1	0	0	$S_1 = 0$
1	0	1	0	1	$S_1 = 1$
1	0	1	1	0	$S_2 = 0$
1	0	1	1	1	$S_2 = 1$
1	1	0	0	0	DPL = 0
1	1	0	0	1	DPL = 1111
1	1	0	1	0	Serial-in ACK = 0
1	1	0	1	1	Serial-in ACK = 1
1	1	1	0	0	Serial-out ACK = 0
1	1	1	0	1	Serial-out ACK = 1
1	1	1	1	0	Request for master = 0
1	1	1	1	1	Request for master = 1

The processor interface is an 8-bit parallel port with appropriate control signals to handshake either with standard I/O systems or through a DMA channel. The DMA handshake allows the use of industry-standard DMA controllers. This high-speed parallel interface can communicate at a full 2-Mbyte rate with an external memory, allowing for very high-speed transfers of data to a host processor.

In addition, this interface is programmable to accept either 8 or 16-bit data from the signal processor's internal bus. If 16-bit data are selected, the upper and lower bytes are automatically multiplexed onto the external data bus, to be recombined externally. When high-speed DMA operations are not required, the μPD7720 may be programmed for the non-DMA mode and addressed as a simple peripheral device in either an I/O or memory-mapped configuration.

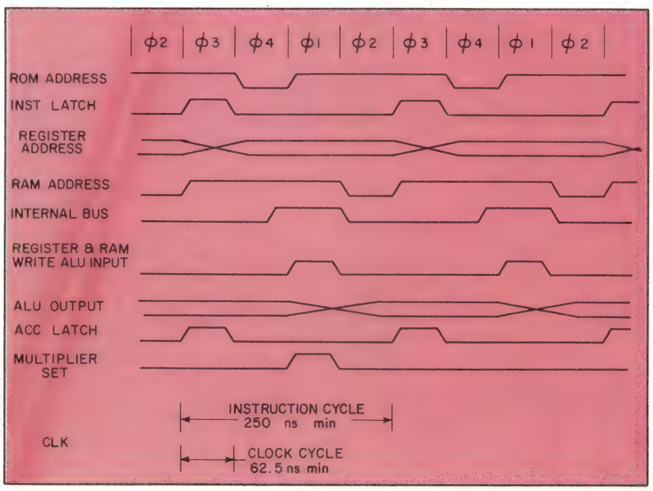
The dual accumulators provide very high-speed operation. Not only does this provide for high-speed temporary storage, but by using both accumulators an instruction can move the last instruction results while making a new calculation with the other accumulator. Each accumulator also has its own set of flags, which means context changes during an interrupt can be performed by switching accumulators—without losing machine status.

Parallel is faster

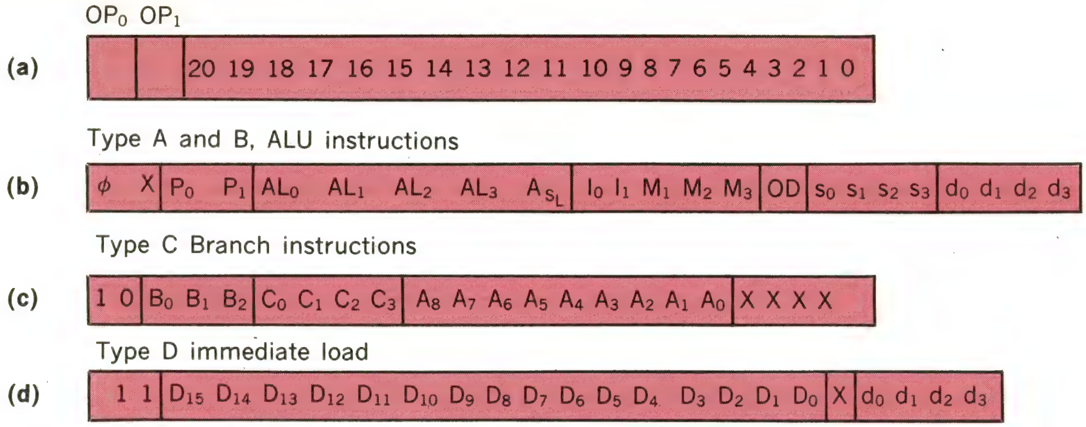
Comparing the μPD7720 with other signal-processing components illustrates the speed advantage achieved with the 16-bit parallel multiplier.

Besides being 50 ns faster than a VMOS component designed with a parallel-serial multiplier, the AMI S2811, the μPD7720 has an instruction ROM capacity of 512 words × 23 bits compared with 256 words × 17 bits for the S2811.

Parallel multiplication shows its distinct advantage when applied to Fast Fourier transforms, for instance. The μPD7720 takes 213 words and 0.7 ms to perform



2. Instruction timing depends on an 8-MHz clock that is divided into a four-phase, nonoverlapping internal clock. Chip architecture allows all instructions to be executed in a single 250-ns cycle.



OP₀ OP₁
(a)
20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0
Type A and B, ALU instructions
(b)
φ X P₀ P₁ AL₀ AL₁ AL₂ AL₃ A_SL I₀ I₁ M₁ M₂ M₃ OD s₀ s₁ s₂ s₃ d₀ d₁ d₂ d₃
Type C Branch instructions
(c)
1 0 B₀ B₁ B₂ C₀ C₁ C₂ C₃ A₈ A₇ A₆ A₅ A₄ A₃ A₂ A₁ A₀ X X X X
Type D immediate load
(d)
1 1 D₁₅ D₁₄ D₁₃ D₁₂ D₁₁ D₁₀ D₉ D₈ D₇ D₆ D₅ D₄ D₃ D₂ D₁ D₀ X d₀ d₁ d₂ d₃

3. Four instruction types are used in the μPD7720. Type A specifies an ALU and simultaneous move operation; type B, all ALU as well as simultaneous move and subroutine; type C, branch; and type D, immediate data load.

a 32-point complex multiplication. The S2811, while using fewer instructions (190), takes 1.5 ms to perform the same operation.

Comparing the μPD7720 with the Intel 2950, an NMOS PROM component that includes an on-chip ADC, the μPD7720 is much faster taking 250 ns for an instruction cycle compared to 400 ns for the 2920; but, of course, the 2920 is giving away speed to the on-board ADC.

Four-phase clock

To control the execution of instructions, the external 8-MHz clock is divided into a four-phase, nonoverlapping clock. Execution begins at the rising edge of $\phi3$ and ends at the falling edge of $\phi2$ (Fig. 2). The ALU commences operation at the rise of $\phi1$, and completes all operations at the fall of $\phi3$.

Once an instruction-ROM address is available at the rise of $\phi3$, the instruction is latched, and the source register and RAM address are determined so that data may be put on the internal bus by the fall of $\phi4$. The ALU input is latched at the rise of $\phi1$, and the output is available for accumulator latch at the rise of $\phi3$. The cycle then repeats.

The multiplier takes its input at the rise of $\phi1$, and its results are available in 250 ns, which means at the rise of the next $\phi1$.

Four types of instruction

The instruction set for the μPD7720 is divided into four types (A through D) selected by the most significant two bits of the 23-bit instruction word. Bits 21 or 22 are the op-code field (Fig. 3a) and designate the instruction type to be performed.

Type A instructions (Fig. 3b) specify an ALU operation and a simultaneous move operation. Type B instructions (Fig. 3b) specify all ALU operations, a simultaneous move operation, and the execution of a subroutine return. Type C instructions (Fig. 3c) specify a branch operation. Note that this particular operation can be either a conditional or unconditional jump on a subroutine call. Type D instructions (Fig. 3d) specify an immediate data-load operation.

For Type A and B ALU instructions, P_0 and P_1 specify the nonaccumulator input to the ALU for the operation to be performed. Field AL_0-AL_3 specifies the ALU operation to be performed as shown in the Instruction Tables. Register ASL specifies which accumulator is to be used as the input to the ALU and the recipient of the ALU results.

Field I_0-M_3 specifies the modification of the DP register, which contains the current address of RAM data. Modifying this register affects the RAM address for the next instruction. The I field modifies the lower-order four bits of the DP register. The M field is EXCLUSIVE-ORed with the highest order of three bits of the DP register to allow total modifications of that register. OD specifies whether the O register should be decremented to change the address of the coefficient RAM for the next instruction.

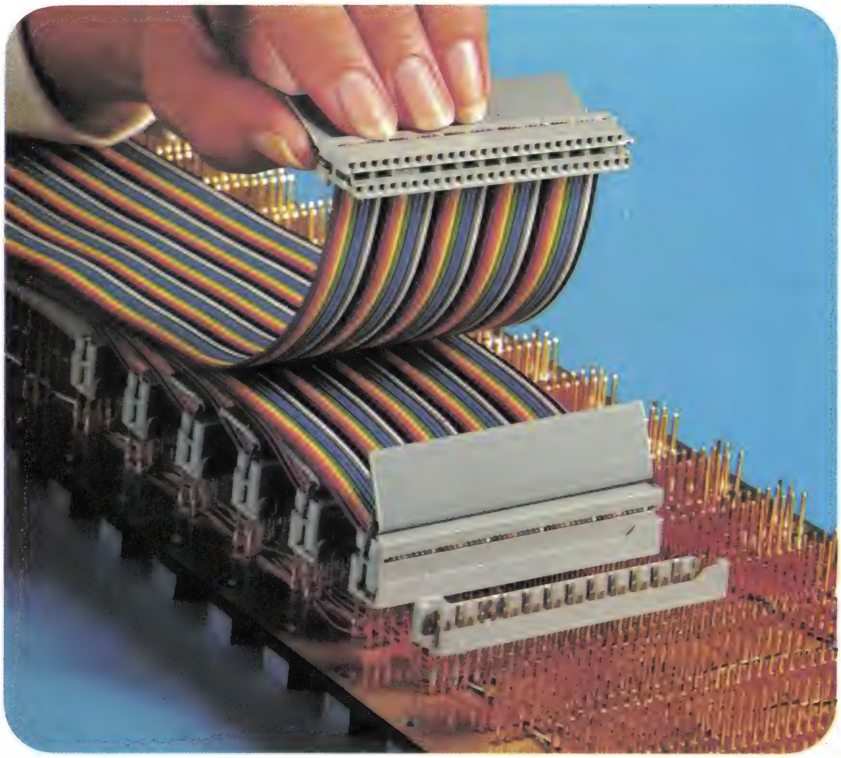
Field s_0-s_3 specifies the source for the simultaneous move, and field d_0-d_3 specifies its destinations as shown in the Instruction Tables.

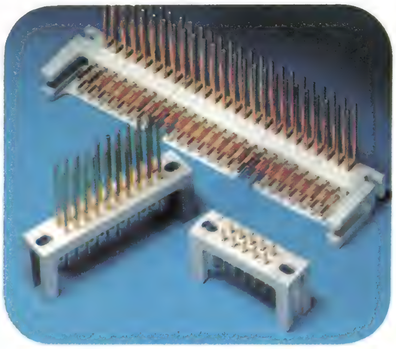
In the Type C branch instructions (Fig. 3c), B_0-B_2 specifies the type of branch to be executed and invalidates other codes. In addition, C_0-C_3 specifies the conditions to be met before a branch is to be executed as shown in the Instruction Tables. Field A_8-A_0 in Type C instructions specifies the new address to be placed in the PC register if the conditions for a branch are met.

For Type D immediate-load instructions (Fig. 3d), field D_{15}-D_0 specifies the immediate data to be placed on the internal data bus and loaded into the specified destination. Field d_0-d_3 specifies the destination for the immediate data, according to the same tables for the Type A and B instructions. ■■

How useful?	**Circle No.**
Immediate design application	**541**
Within the next year	**542**
Not applicable	**543**

Want simpler backplane connections? Come to the source.





Now, a unique Scotchflex brand Socket Connector and Keying Header system lets you interface directly with backplane wrap pins and provides for easy, positive polarization and keying. The header design allows for thousands of unduplicated polarizing combinations without loss of backplane pins. The 50-position connector mates with .025″ square pins on .100″ x .200″ grid spacing. Header allows space for and protects two layers of wrap below it. System also provides polarizing keys and strain relief handles.

Need some other ways to simplify wiring and increase circuit density? 3M's Scotchflex line offers you a broad choice of mass terminating socket connectors, plus wrap tail or solder tail headers to suit your specific design problem. Keying capability is also provided.

There are several more things you can get only from 3M. The broadest range of flat cables and complete system components. Best off-the-shelf availability. Proven performance. And the unmatched experience of the people who pioneered this reliable mass termination system.

For more information on Scotchflex products call 612-733-3350.

"Scotchflex" is a registered trademark of 3M Co.

Scotchflex® systems from 3M. The source.

See our catalog in EEM

3M

CIRCLE NUMBER 33

Computer systems acquire both RAM and E^{2}PROM from one chip with two memories

One TTL-compatible chip puts both E^{2}PROM and RAM storage at the disposal of a computer system. The 1 k × 1 chip is organized with two independent bit-for-bit overlayed memory areas (Fig. 1). One area is a standard 1024-bit RAM. The other, a "shadow" memory, is a 1024-bit, electrically erasable, nonvolatile memory.

The chip array comes in two versions, the X2201 and the X2202; both can operate from just a 5-V supply. Their design is based on a version of the floating-gate principle that makes it possible to alter the devices electrically.

In normal use, data are read from and written to the RAM section of the chip. When data must be stored before the power goes off, a TTL-compatible control signal automatically transfers the data into the nonvolatile storage area.

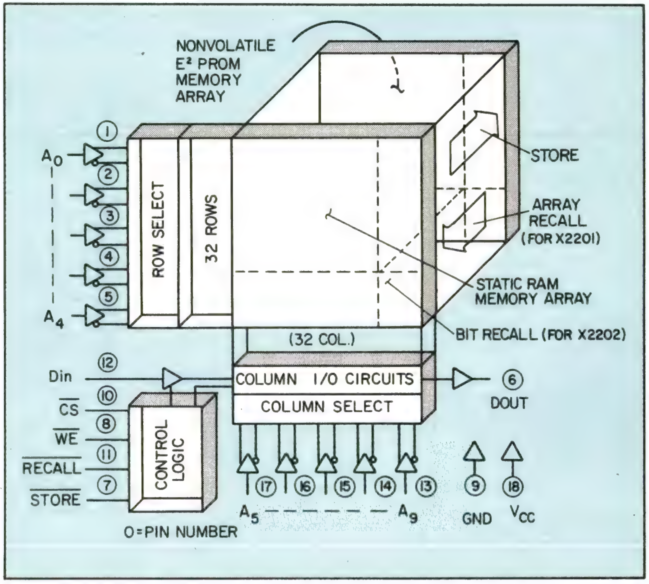
At any time, data can be transferred back and forth between the static RAM and nonvolatile memory, using simple $\overline{\text{STORE}}$ and $\overline{\text{RECALL}}$ signals. For some applications, two separate bits of data can be stored, one in the conventional static RAM and the other in the nonvolatile memory. This flexible architecture opens many design possibilities, including software changes directly loaded by software command.

Simple interfaces for nonvolatile RAM

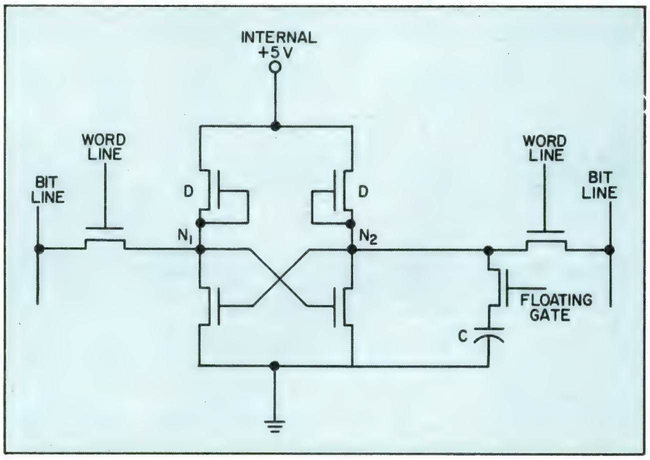
Using the X2201 or 2202 is relatively easy since all lines are TTL-compatible, and each device requires just a single 5-V supply. The schematic in Fig. 2 indicates how the nonvolatile element is interfaced to the six-transistor, depletion-loaded, static-RAM cell via the floating-gate control. When the X2201 or 2202 operates as a normal static RAM, the high-impedance load of capacitor C has no effect; the cell is written or read as in any static memory.

All data are read from the RAM or written into the RAM; at any time, data can be stored in the nonvolatile E^{2}PROM by copying the entire RAM array in parallel with the application of the TTL-compatible $\overline{\text{STORE}}$ signal (Fig. 3a). The process takes 4 ms maximum, but continues automatically once it is initiated. The RAM data are still available, and routine RAM operations can continue.

If a $\overline{\text{RECALL}}$ signal is applied, the permanently stored data in the E^{2}PROM section are copied back into the RAM section (Fig. 3b).

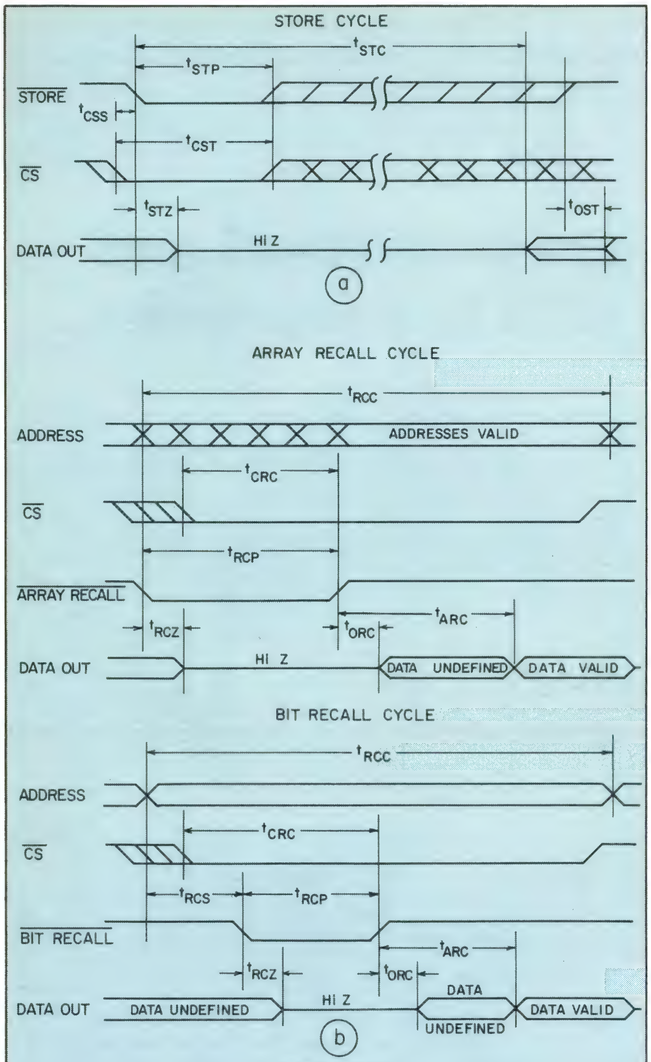


1. **Containing two 1024-bit arrays, one a static RAM and the other an E^{2}PROM, the X2201 and 2202 nonvolatile RAMs come in 18-pin DIPs and perform like a 2102A, but also retain data when the power goes off.**



2. **Consisting of a basic six-transistor static-memory element, a capacitor and a control transistor, each cell in the nonvolatile RAM can store two bits—one in the RAM section and one in the nonvolatile area.**

Joseph Drori, Design Manager, **William H. Owen,** Director of Engineering, and **Richard T. Simko,** Director of Technology, Xicor, 1221 Innsbruck Dr., Sunnyvale, CA 94086.



3. The X2201 and 2202 are as easy to use as static RAMs, as indicated by store (a), recall (b) and read and write (c) timing diagrams. One point to note on the store timing diagram (a) is that the store pulse need be only 100 ns wide, although the store cycle requires about 4 ms; internal logic on the memory chip takes over and controls the entire cycle.

The X2201 recall feature uses a signal called ARRAY RECALL, which, in a single operation, brings the entire 1024-bit array back into the RAM. The X2202 has a BIT RECALL signal that transfers a single address-selected bit of E²PROM data into the corresponding address in the RAM. This transfer is completed in less than 1.5 μs.

Once data are in the RAM, they can be read or modified as in any other static RAM (Fig. 3c). A copy of the original E²PROM data remains unaltered in the nonvolatile section.

The RAM sections of the memory devices have a cycle time of less than 250 ns. The data outputs are three-state so that several devices can be connected to the same bus without buffering.

One application for the nonvolatile RAMs would be storing a bootstrap program in the shadow memory. At the same time, the system could access an independent program in the RAM section.

Another application would be as a power-failure protection circuit. A simple TTL signal could save the entire RAM data base. Just 4 ms would be needed to save 1024 bits of data; or, if multiple memories were used in an array, just 4 ms per bank. When power was restored, all data could be loaded back into the static RAM arrays from the nonvolatile areas. To do so merely requires pulsing the RECALL line.

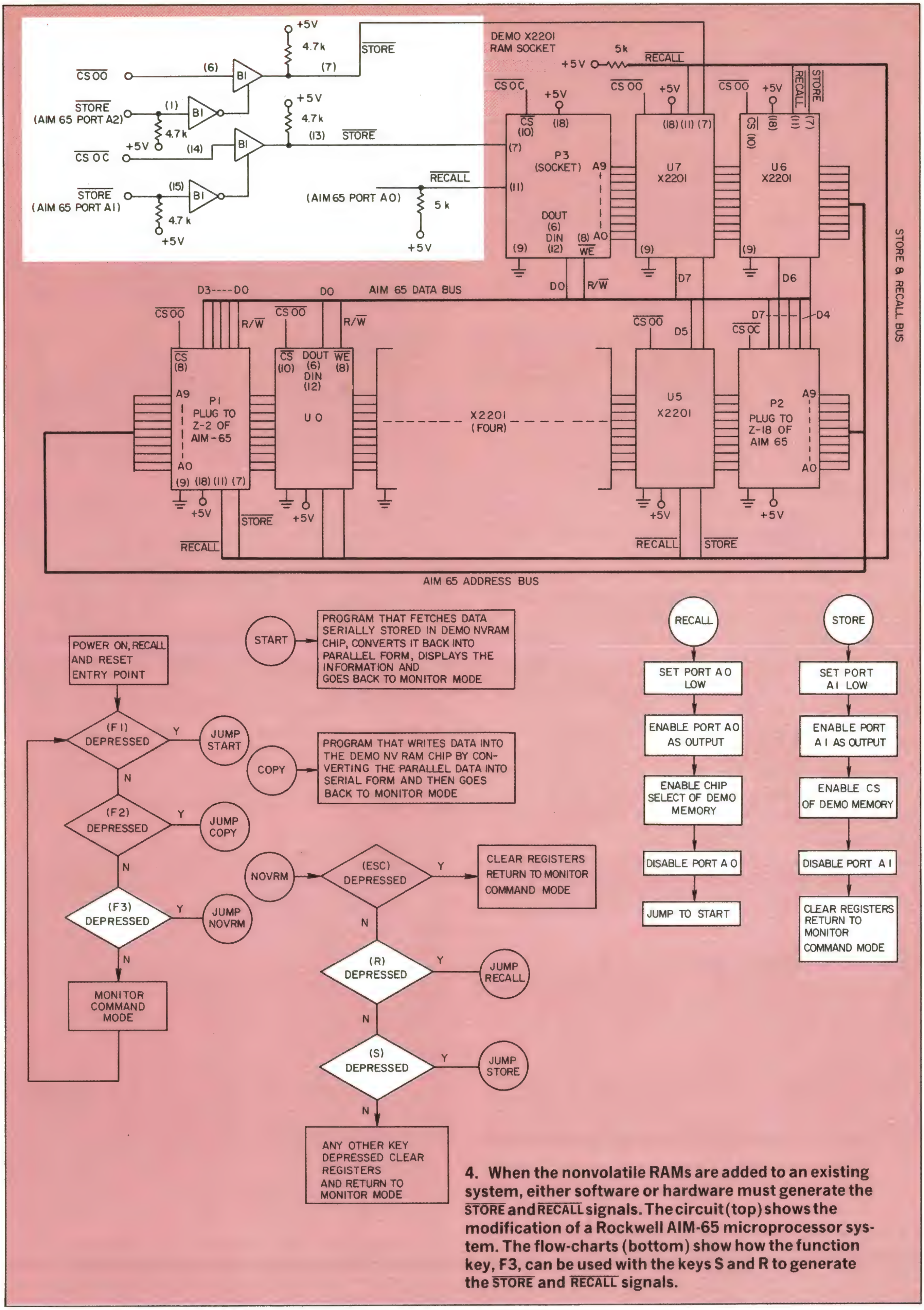
Design an actual system

As an example of designing a system around the nonvolatile RAMs, the circuit in Fig. 4 uses the devices for nonvolatile program storage. Small, experimental microcomputer systems are a prime candidate for this type of memory, since in many cases programs must be hand-loaded into the system; but when power is turned off, all data are wiped out. In Fig. 4a, the Rockwell International AIM-65 incorporates nonvolatile RAMs to prevent such data losses.

Eight of the X2201s are connected to appear as an ordinary RAM. However before the system power is shut off, the store pulse is applied and all the RAM data are stored in the E²PROM array. When the system power is turned back on, all data from the E²PROM array are automatically transferred back into the RAM section, and program development can continue.

On the AIM-65, the programmable function key, F3, combines with the S key (FS-3) to generate the store pulse; it combines with the R key (FS-R) to generate the recall pulse. The STORE and RECALL signals are tapped from the AIM-65 ports A0, A1 and A2. Fig. 4b shows flow charts of the algorithms needed to define the operations. To tap into the actual circuitry of the AIM-65, the user must access the data and address buses, as well as the R/W and CS00 and CS0C control lines.

In addition to the eight X2201s, just a switch, a hex buffer (74367) and some resistors must be added. Some of the resistors ensure that no accidental store opera-



4. When the nonvolatile RAMs are added to an existing system, either software or hardware must generate the $\overline{\text{STORE}}$ and $\overline{\text{RECALL}}$ signals. The circuit (top) shows the modification of a Rockwell AIM-65 microprocessor system. The flow-charts (bottom) show how the function key, F3, can be used with the keys S and R to generate the $\overline{\text{STORE}}$ and $\overline{\text{RECALL}}$ signals.

tions take place upon power-up by keeping the memory control lines in the high state until they are intentionally brought low.

For demonstration purposes, a ninth nonvolatile RAM, which can be written to and read from, has been set up in socket P_3 with all its pins connected in the same way as memories U_0 to U_7. The one difference is that both the data in and data out pins of the demo chips are connected to the D_0 line of the data bus; this permits simple data transfers from serial to parallel mode and vice versa. The demo chip uses the CS0C and port A_0 and A_1 signals for control.

New tricks with existing technology

Like their UV-EPROM cousins, the X2201 and 2202 are floating-gate structures that use standard n-channel silicon-gate processing. In the floating-gate structure, an island of conducting material is capacitively coupled to the substrate, forming a transistor. Depending on whether a charge is on the gate, the transistor will be on or off. Once the charge is on the gate and the programming voltage is removed, the charge remains permanently trapped, since the floating-gate is completely surrounded by oxide, which acts as a barrier to discharge.

Several processes may occur during nonvolatile write cycles that could limit nonvolatile programming to between 10^3 and 10^6 cycles. However, improvements are expected in this area. The excellent data retention and unlimited read cycles of floating-gate devices are more important in many applications than a need for unlimited write cycles.

The X2201 and 2202 RAM/E²PROMs differ from UV EPROMS and from many of the available MNOS E²PROMs in the way the signal charge is introduced and retained by the gate. In Xicor's devices (Fig. 5a), current flows between three levels of polysilicon. A scanning electron-microscope photograph (Fig. 5b) shows the layout of the three layers: The second layer is the floating gate, the first layer is the programming area and the third layer is the erasing area.

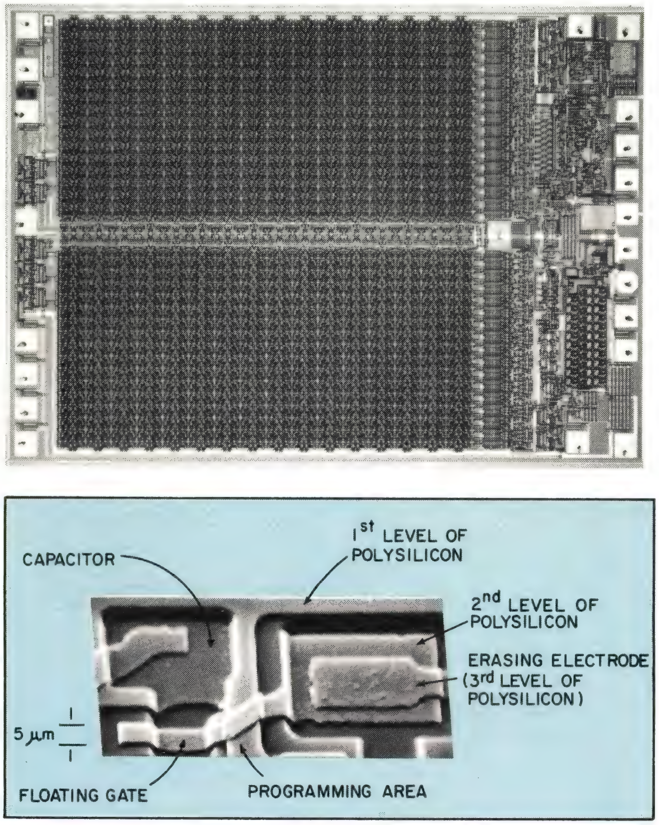
Program and erase—redefined

In the X2201 and 2202, the words "program" and "erase" take on new meanings, since there is no need to initialize the devices to a single state with exposure to UV light.

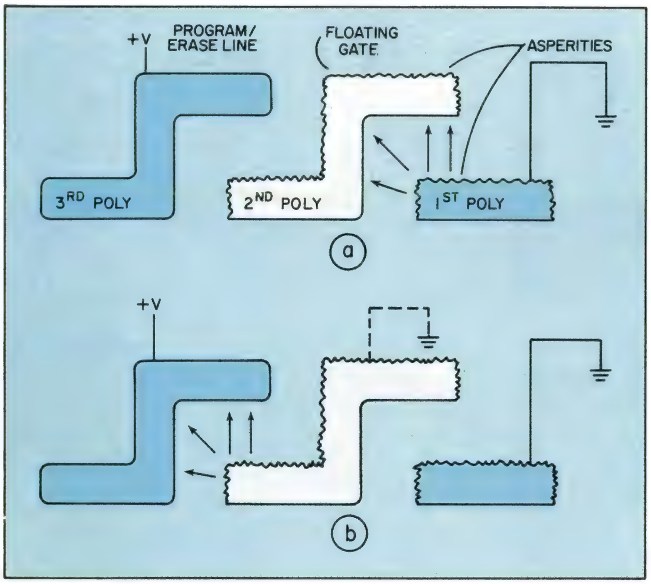
The $\overline{\text{STORE}}$ signal transfers the contents of the static RAM section into the shadow E²PROM area. To put the memory into a known starting state, each bit of the RAM must be written to (which would require about 256 μs at 250 ns/bit) and then the entire contents must be stored (about 4 ms) in the E²PROM section.

When the floating gate is charged with electrons, the transistor turns off and the nonvolatile cell is programmed. When electrons are removed from the floating-gate, the transistor turns on and the cell is erased. A programmed floating-gate stays at a negative potential; an erased floating-gate keeps its positive potential.

When the program/erase line (Fig. 6a) is brought from ground to a positive voltage (through a control sequence initiated by the store pulse), the floating-gate is capacitively carried to a positive voltage. The negative charge leaves the floating-gate, when the



5. With a chip size of just 164 × 118 mils, the nonvolatile RAMs (the X2201 is shown here) provide a 1-k × 1 array (top). This close-up of a cell (bottom) shows how the triple polysilicon structure provides the extra electrode necessary for a nonvolatile RAM.



6. A floating gate becomes negatively charged (a) or positively charged (b) when the various electrode elements are pulled to the correct potentials by the on-chip control logic.

internal program/erase line is again brought high (Fig. 6b). Since the floating gate is held close to ground potential, a strong electric field is built between the program/erase electrode and the floating gate. Under these circumstances, the second-layer floating gate emits electrons to the program/erase electrode, and the floating gate becomes positively charged.

The electron flow depends on enhanced tunnel current between the three levels of polysilicon. The oxides separating the levels of polysilicon are approximately 1000 Å thick. Normally, no appreciable tunnel current would be expected to flow between electrodes separated by such thick oxides unless high voltages were applied (greater than 100 V).

However, for many years observers have noted that current, many orders of magnitude larger than expected, flows between polysilicon electrodes at relatively low applied voltages. This enhanced tunneling results from the textured surface of the polysilicon, which produces field-aided emissions. The textured surface contains objects called asperities, which exist uniformly across the polysilicon layer on the wafer.

Many studies of polycrystalline silicon have shown that SiO_2 conducts better when it is thermally grown on the surface of the polycrystalline silicon than when it grows on the smooth-surface single-crystal silicon, because of these submicroscopic asperities.[1-4] The asperities provide localized field-enhancement and Fowler-Nordheim tunneling injection at moderate electric field strengths, even when electrodes are separated by 1000 Å. This practical manufacturing process permits the manufacture of nonvolatile RAMs with today's semiconductor technology.

The enhanced electron tunneling mechanisms are very efficient compared to techniques using avalanche breakdown or hot-electron emission. In the latter only a small fraction of the programming currents ever reach the floating gates. The large currents and high voltages required for the inefficient structures are not consistent with future LSI requirements. By combining a nonvolatile structure, TTL-compatibility, operation from a 5-V supply and standard n-channel MOS processing in its devices, Xicor has raised the possibility of including nonvolatile capability in circuits other than memories. ▪▪

References

1. Iizuka, H.; Sato, T.; Masuoka, F.; Ohuchi, K.; Hara, H.; Tango, H.; Ishikawa, M.; and Takeishi, Y., *Suppl. J. Japan Soc. Appl. Phys.*, Vol. 42 (1973), p. 158.
2. Abbas, S.A., and Barile, C.A., *13th Annual Proceedings*, Reliability Physics Symposium, Las Vegas, NV, 1975, Vol. 13, p. 1.
3. Diaria, D. J., and Kerr, D. R., *Applied Physics Letters*, Vol 27 (1975), p. 505.
4. Anderson, R.M., and Kerr, D.R., *Journal of Applied Physics*, Vol. 48 (Nov. 1977), No. 11.

How useful?	**Circle No.**
Immediate design application	**544**
Within the next year	**545**
Not applicable	**546**

TRANSISTOR SOCKETS

NEWLY DESIGNED SNAP-IN SOCKETS FOR TO-3 & TO-66

The most complete line of transistor sockets and mica insulators in the industry. Our sockets are designed for the TO-3 and TO-66 transistors. Available from stock. Introducing our latest design in printed circuit sockets plus an extensive line of snap-in sockets. Sockets are available in the latest UL approved materials.

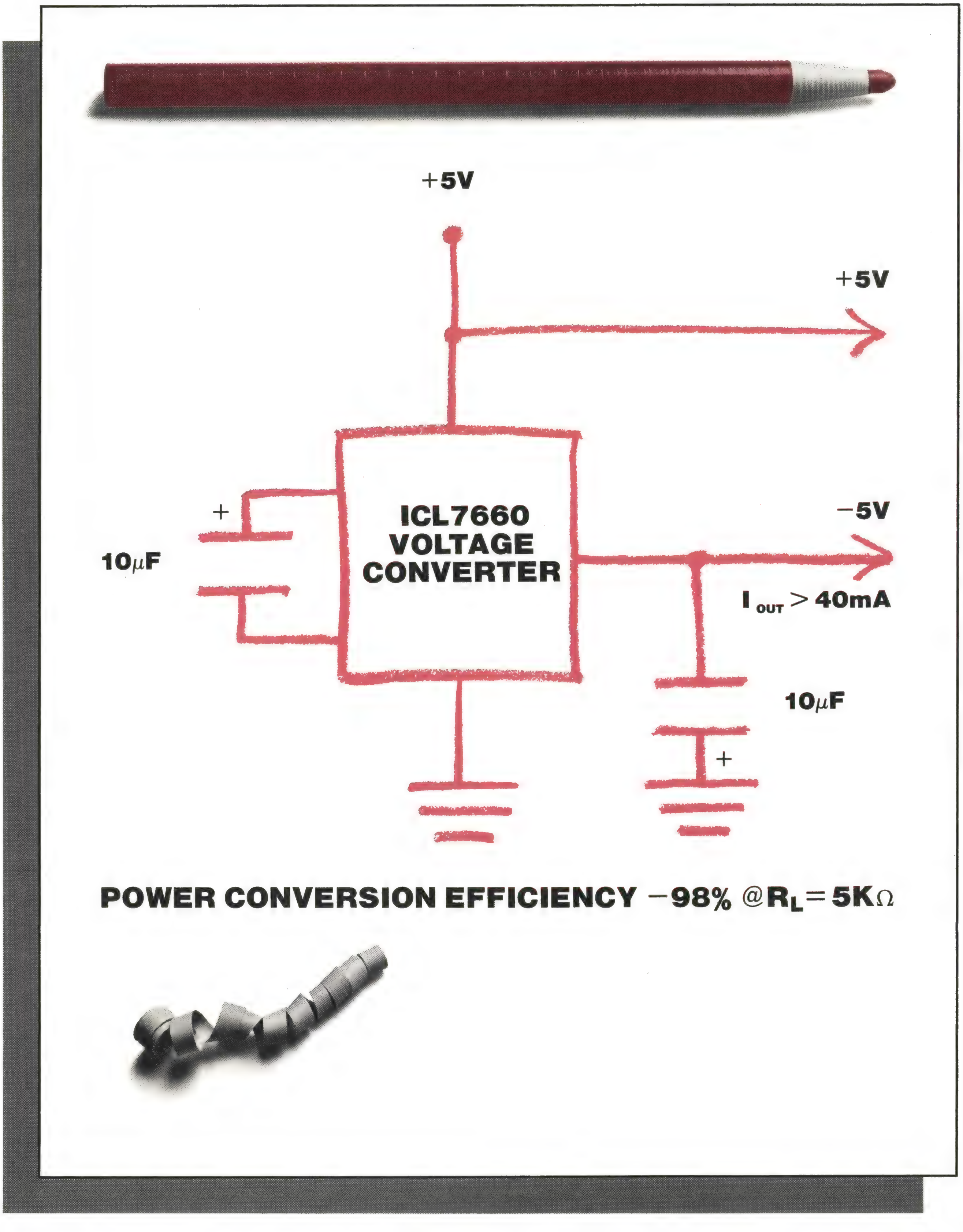
NEW FREE CATALOG ON REQUEST

DESIGNERS MANUFACTURERS

KEYSTONE
ELECTRONICS CORP.
TWX 710-581-2861 CABLE-KEYELCO
49 BLEECKER STREET, NEW YORK, N.Y. 10012 212-475-4600

CIRCLE NUMBER 35

OF COURSE YOU NEVER VOLTAGE CONVERTER.



POWER CONVERSION EFFICIENCY −98% @$R_L = 5K\Omega$

HEARD OF A MONOLITHIC WE JUST INVENTED IT.

+5V IN. −5V OUT.

Now, you can power your analog circuitry from your digital power supply. With a single chip. The ICL7660 monolithic voltage converter generates the negative voltages required by the analog functions in your system. Or, one ICL7660 provides −5V for a board-full of dynamic RAMs. +5V in. −5V out. Or, +1.5V to +10V in and −1.5V to −10V out. Require higher negative voltages? Cascade 7660's. Need more current? Just put 'em in parallel.

EFFICIENCY PLUS.

Intersil's MAXCMOS™ process brings you another first. A monolithic voltage converter with a voltage conversion efficiency of 99.9% ($R_L = \infty$). Power conversion efficiency of 98% ($R_L = 5K\Omega$). And I_{OUT} capability greater than 40mA ($R_{OUT} = 55\Omega$). You simply can't beat it. Period.

NO MORE KLUGES.

One chip and two caps. Put 'em wherever you need 'em. And the ICL7660 virtually eliminates EMI problems caused by inductive converters.

GOOD NEWS.

- Monolithic
- Short circuit protection
- Latch-up proof
- 1.5 to 10V operation
- Direct parallelling for more output current
- Operates in simple voltage multipliers: $V_{OUT} = -nV_{IN}$.

MORE GOOD NEWS.

The ICL7660 monolithic voltage converter costs just $1.95 in lots of 100 (8-pin epoxy DIP). Be sure to ask for quantity prices.

THE SYSTEMS APPROACH.

The Intersil MAXCMOS™ process, coupled with our broad experience in data acquisition products, has led to a continuing series of high performance, low-power analog and data conversion products. Analog products that operate from a ±5V supply. And now, a monolithic voltage converter that powers analog functions from your digital supply.

MORE INFORMATION?

Call your Intersil Sales Office, Franchised Distributor, or return the coupon below. The ICL7660 is available now. In prototyping or production quantities.

INTERSIL SALES OFFICES:

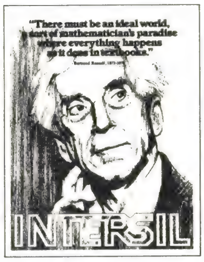
CALIFORNIA: Sunnyvale (408) 744-0618, Long Beach (213) 436-9261 • COLORADO: Aurora (303) 750-7004 • FLORIDA: Fort Lauderdale (305) 772-4122 • ILLINOIS: Hinsdale (312) 986-5303 • MASSACHUSETTS: Lexington (617) 861-6220 • MINNESOTA: Minneapolis (612) 925-1844 • NEW JERSEY: Englewood Cliffs (201) 567-5585 • OHIO: Dayton (513) 866-7328 • TEXAS: Dallas (214) 387-0539 • CANADA: Brampton, Ontario (416) 457-1014

INTERSIL FRANCHISED DISTRIBUTORS:

Advent (IND, IA) • Alliance • Arrow • Bell Industries • CESCO • Component Specialties • Components Plus • Diplomat (FLA, MD, NJ) • Harvey (upstate NY) • Intermark • Kierulff • LCOMP • Parrott • R.A.E. Ind. Elect. Ltd. • RESCO/Raleigh • Schweber • Summit • Wyle • Zentronics Ltd.

INTERSIL

ANALOG PRODUCTS—
LINEAR CIRCUITS
10710 No. Tantau Ave., Cupertino, CA 95014
Tel: (408) 996-5000 TWX: 910-338-0171
(800) 538-7930 (outside California)


"There must be an ideal world, a sort of mathematician's paradise where everything happens as it does in textbooks."
Bertrand Russell, 1872-1970
INTERSIL

Gentlemen:

+5V in and −5V out? Monolithic? Send me the details on your ICL7660.

_____ While you're at it, send me your 20″ x 24″ Bertrand Russell poster.

Name____

Company____

Address____

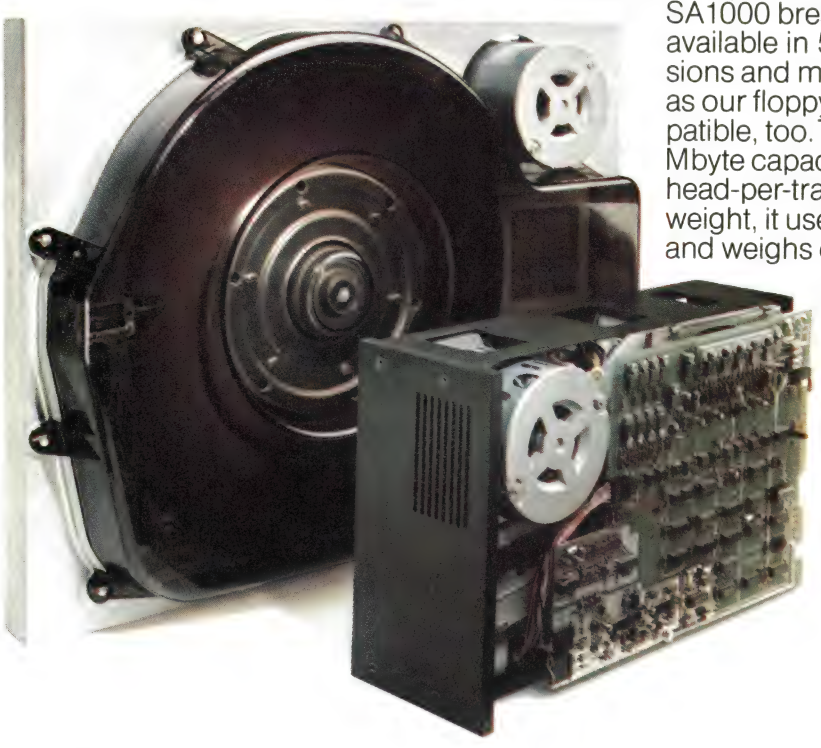
City____ State____ Zip____

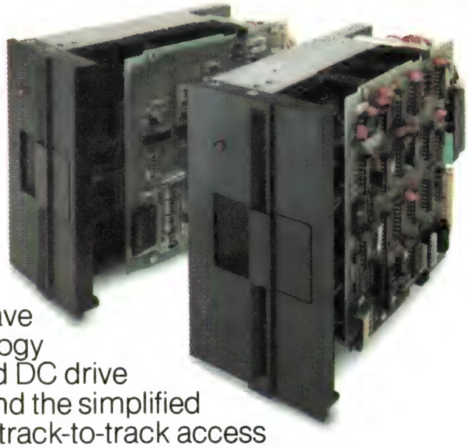
ED21580

Want 400-1600 Kbytes? Choose our SA801/851 series. With the SA801 8-inch floppy, you have a choice of 400 or 800 Kbytes in single or double density, on the same drive for the same price. More than 400,000 of these standard-setting drives have been specified by OEM's around the world. They know that they can count on Shugart's proprietary read/write head technology to deliver media life of over 3.5 million passes per track, and head life of more than 15,000 hours. That's headstrong performance. And the double-sided SA851 drive gives you even more capacity. It stores 800 to 1600 Kbytes using single or double density recording. The 851's proprietary Fasflex™ band actuator improves track-to-track access time to a fast 3 ms. There's also a programmable door lock and write protect. The headstrong SA801/851. Solid performers from the leader in floppy technology.

The head
Choose your

Moving up to 5-29 Mbytes? Check Shugart's SA1000 and SA4000 fixed disk drives with the lowest cost per Mbyte in their capacity range. The new 8-inch SA1000 breaks the $1,000 price barrier and is available in 5 and 10 Mbyte versions. Its dimensions and mounting holes are exactly the same as our floppy drives, and it's electrically compatible, too. The SA4000 offers 14.5 and 29 Mbyte capacity with an optional 144 Kbytes of head-per-track storage. Compact and lightweight, it uses only 5¼ inches of panel space and weighs only 35 pounds. All Shugart fixed disk drives use proven Winchester head and media technology to ensure better data integrity and longer trouble-free life. And system integration is easy because both the SA1000 and SA4000 can share a power supply with your floppy drives. Shugart fixed disk drives. The head of the family in capacity and cost/performance.

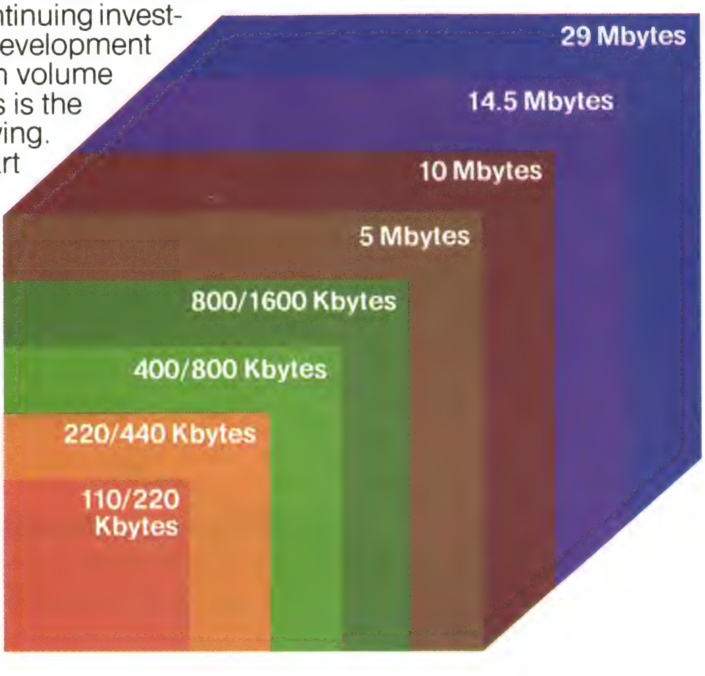




Need 110-440 Kbytes? The famous Minifloppy™ is the right choice. The Minifloppy stores from 110 to 440 Kbytes in a package about half the size of a standard floppy. We invented the Minifloppy family just two years ago and there are already well over 150,000 installed world wide. Compact size, reliability, and lowest cost per function are the reasons. Minifloppy drives have the same headstrong read/write head technology as their big brothers. The servo-controlled DC drive motor eliminates AC power requirements and the simplified actuator with direct drive spiral cam gives you track-to-track access as fast as 25 ms. The little drives offer the lowest heat dissipation of any floppy drive and feature positive media insertion, write protect, and activity light. Minifloppy. The original, and still the most popular 5¼-inch floppy drive in the world.

strong family.
capacity.

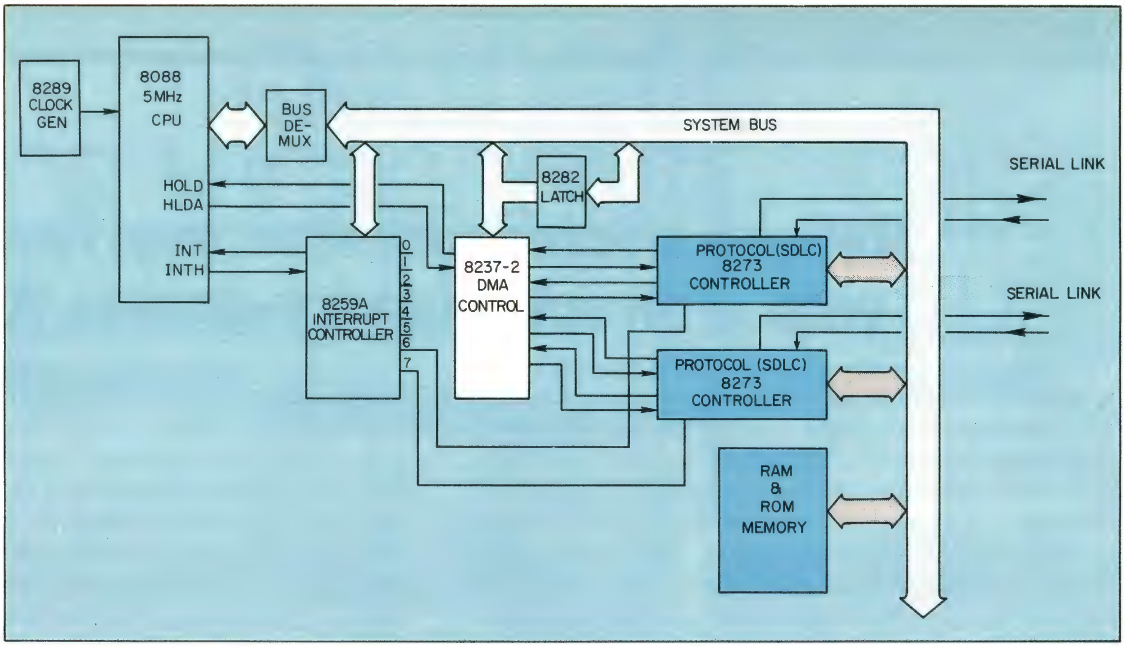
The Shugart Family. Headstrong and proud of it. We're headstrong about our commitment to our customers. This means supplying you with a family of highly reliable, low cost disk drives in the quantities you need. And it means providing you with the best technical support and documentation in the industry. But it goes deeper. Like maintaining in-house control over the design and manufacture of 100% of our floppy read/write heads. And the continuing investment of financial and human resources in the development of new products and the most modern high volume manufacturing facilities in the business. This is the commitment that keeps our family growing. Headstrong? You bet. And proud of it. Shugart Associates Headquarters: 435 Oakmead Parkway, Sunnyvale, California 94086 (408) 733-0100; West Coast Sales/Service: (408) 737-9241; Midwest Sales/Service: (612) 574-9750; East Coast Sales/Service: (617) 893-0560; Europe Sales/Service: Paris (1) 686-00-85; Munich (089) 176006; Shugart products are also available off the shelf from local Hamilton Avnet outlets.



Shugart

The Headstrong Company

CIRCLE NUMBER 34



1. In a serial, two-channel, full-duplex communications link (part of an 8088-μP communications processor), an 8237-2 controls DMA data transfers between the serial links and main memory.

bus-time between DMA cycles.)

The burst mode operates like the single-byte mode, except that an entire block of data (with its length defined by the terminal-count register) is transferred for each DRQ activation. In the burst mode, the timing constraints for the DRQ signal are less stringent than in the demand mode. When the length of the transfer is known beforehand, the burst-transfer mode is the best way to handle block transfers.

The cascade mode allows a second slave 8237 to be cascaded through one channel of a master 8237 to provide additional DMA channels. In the cascade mode, a channel in the master DMA unit resolves priorities and issues the bus-hold request; the slave, or cascaded, 8237 drives the address and control buses during the DMA cycles.

Four clock cycles/byte

A complete burst transfer requires four clock cycles per byte (800 ns with a 5-MHz clock), which makes the throughput rate 1.25 Mbytes/s. However, not all burst transfers need all four cycles: The first clock cycle latches the most-significant eight address bits into an external latch. Since the contents of the latch needs to change in only one transfer cycle out of every 256, just three clock cycles are needed for all but the first byte of most burst transfers. The actual burst throughput rate, therefore, will approach the top value of 1.6 Mbytes/s.

A more meaningful way of demonstrating the 8237's effectiveness in handling data transfers at high speed is to examine a specific task. For example, a typical CRT-refresh cycle for an 80-character, 24-line CRT display, which is refreshed 60 times per second, requires a transfer rate of 115,200 chars/s, or 460,800 clocks/s. With a 2-MHz, 8080A system (without an 8237), the refresh cycle would take 230 ms out of each second of system time, or 23% of total system time. In a 5-MHz, 8085A-2 system (with an 8237), the refresh needs just 92 ms/s, or 9.3% of the system time.

Clearly, CRT refresh with the combined 8085A-2 and 8237 consumes a much smaller percentage of total CPU time, and thereby substantially raises overall system throughput. In the burst-mode, the 8237 could save even more: Data in 8-byte bursts would reduce overhead to just 83 ms/s.

However, the burst mode is not the best choice for an 8088 and 8237. Unlike an 8085A-2, an 8088 system generally continues functioning during DMA transfers: The 8088 CPU can execute instructions during a hold state, as long as there are instructions in its internal queue, or until a memory reference is required. Because throughput is not affected by CRT refresh, as it is with the 8080 or 8085, an 8088 system with an 8237 gets the least overhead in the single-byte transfer mode. In most cases, DMA transfer is completely invisible to an 8088. This concurrent processing ability is a key advantage of 8088-family processors.

DMA controls data movement

A typical application of the 8237 is in a two-channel, full-duplex communications link (Fig. 1), consisting mainly of a CPU and line-protocol controllers (such as the 8273 SDLC). The 8237 controls the movement of data between memory and protocol-controller peripherals, byte-by-byte, whenever the peripheral requests such service. This process entails considerable overhead, which could tie up the CPU in a high-speed

Pin nomenclature

V_{cc} — +5 V, **V_{ss}** — ground

CLK *(Clock, Input)* — controls internal operations and rate of data transfers.

CS *(Chip Select, Input)* — enables the 8237 as an I/O device during Idle cycles to allow CPU communication on the data bus.

RESET *(Reset, Input)* — asynchronously clears the Command, Status, Request and Temporary registers. Also, it clears the first/last flip-flop and sets the Mask register. Following a Reset, the device is in the idle cycle.

READY *(Ready, Input)* — extends read and write pulses to accommodate slow memories or I/O peripheral devices.

HLDA *(Hold Acknowledge, Input)* — indicates that control of the system buses has been relinquished.

DREQ0-DREQ3 *(DMA Request, Input)* — are individual asynchronous channel request inputs from peripherals to obtain DMA service. In Fixed Priority, DREQ0 has the highest priority and DREQ3 has the lowest priority.

DB0-DB7 *(Data Bus, Input/Output)* — are bidirectional three-state signals connected to the system data bus.

$\overline{\mathrm{IOR}}$ *(I/O Read, Input/Output)* — is a bidirectional, three-state line. In Idle cycle, it is an input to read the control registers; in Active cycle, it is an output to access data from a peripheral during a DMA Write transfer.

$\overline{\mathrm{IOW}}$ *(I/O Write, Input/Output)* — is a bidirectional, three-state line. In Idle cycle, it is an input to receive information; in Active cycle, it is an output to deliver data to the peripheral during a DMA Read transfer.

EOP *(End of Process, Input/Output)* — is a bidirectional signal indicating the completion of DMA services. An external signal can terminate an active DMA service (by pulling the EOP input low), or the 8237 can generate an output pulse when the terminal count (TC) for any channel is reached.

A0-A3 *(Address, Input/Output)* — are the four least-significant address lines, bidirectional and three-state. In Idle, they are inputs to address the control register. In Active, they are outputs and provide the lower 4 bits of the output address.

A4-A7 *(Address, Output)* — are the four most-significant address, three-state lines. They are enabled only during DMA service.

HRQ *(Hold Request, Output)* — requests control of the system bus.

DACK0-DACK3 *(DMA Acknowledge, Output)* — notifies a peripheral when it has been granted a DMA cycle.

AEN *(Address Enable, Output)* — enables the 8-bit latch containing the upper eight address bits onto the system address bus. Also, it can disable other system bus drivers during DMA transfers.

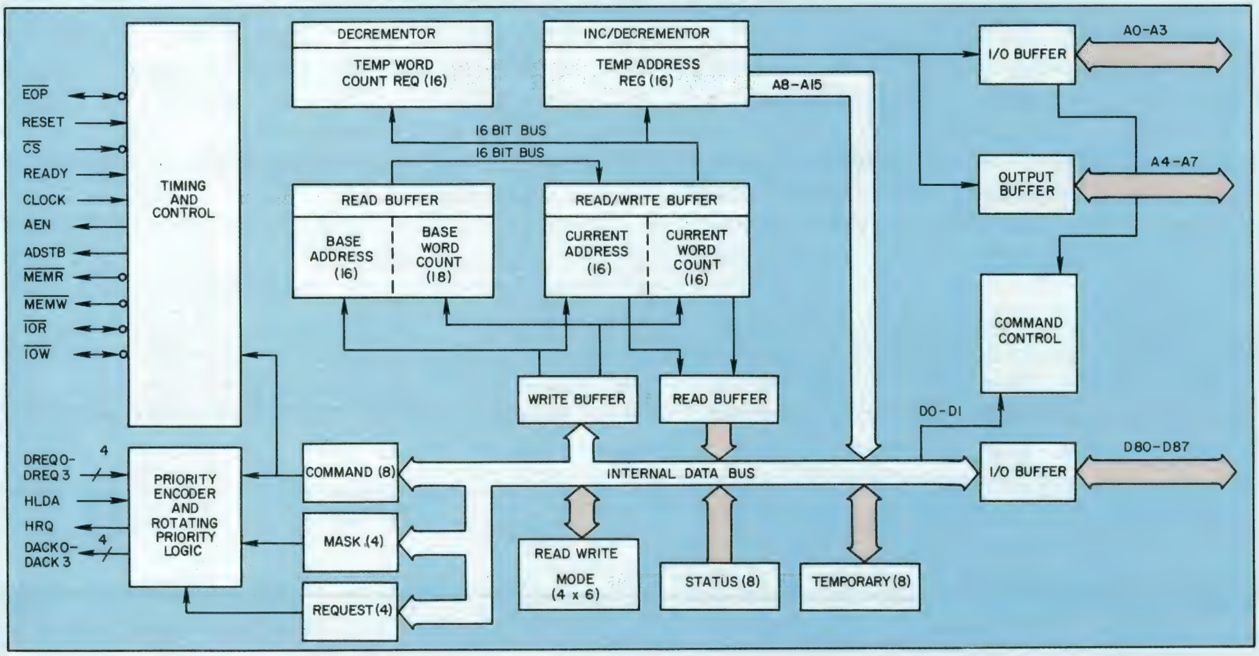
ADSTB *(Address Strobe, Output)* — strobes the upper address byte into an external latch.

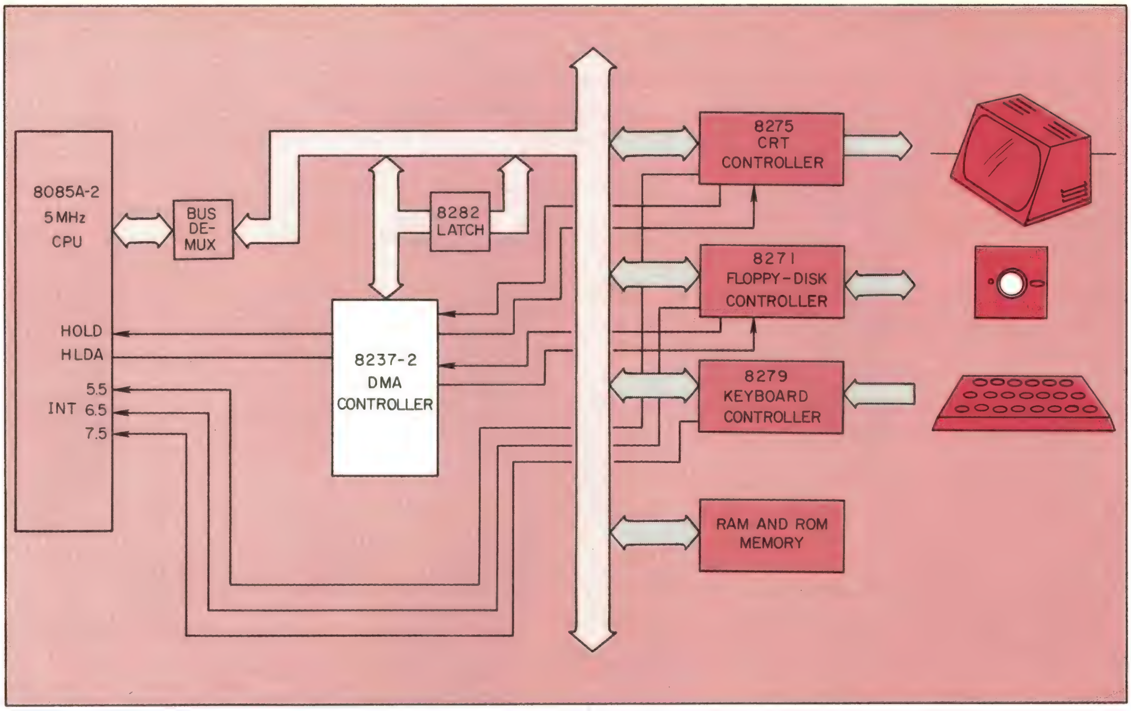
$\overline{\mathrm{MEMR}}$ *(Memory Read, Output)* — is a three-state output that accesses data from a selected memory location during a DMA Read or a memory-to-memory transfer.

$\overline{\mathrm{MEMW}}$ *(Memory Write, Output)* — is a three-state output that writes data to the selected memory location during a DMA Write or a memory-to-memory transfer.

Internal registers

Name	Size	No.
Base Address Registers	16 bits	4
Base Word Count Registers	16 bits	4
Current Address Registers	16 bits	4
Current Word Count Registers	16 bits	4
Temporary Address Register	16 bits	1
Temporary Word Count Register	16 bits	1
Status Register	8 bits	1
Command Register	8 bits	1
Temporary Register	8 bits	1
Mode Registers	6 bits	4
Mask Register	4 bits	1
Request Register	4 bits	1





2. An intelligent terminal based on the 8085A-2 has significantly more throughput when an 8237-2 controls DMA transfers to and from the floppy-disk controller, and also handles the CRT refresh.

data line. However, the 8237 DMA controller relieves the CPU of the overhead tasks by providing a direct path between memory and the protocol controller.

The peripheral requests a transfer of a data byte, whenever its transmitter becomes empty (or its receiver becomes full) by activating one of the four DMA request lines. The 8237 then raises the hold (HRQ) signal to the CPU to request the use of the system bus. The CPU responds (as soon as it has finished its current bus cycle) with an acknowledge (HLDA) signal to the 8237.

The 8237, now free to use the bus, proceeds with a memory cycle—first, selecting the peripheral (after a DACK); then, issuing memory-read and I/O write signals for memory-to-peripheral transfers, or issuing memory-write and I/O read signals for peripheral-to-memory transfers. In this manner, a byte is transferred into or out of the system's memory with a minimum of system overhead: Only one bus cycle transfers a byte, where 20 to 50 bus cycles would be needed for an interrupt-response-and-return cycle without the 8237.

In a multiple-DMA-channel application of this type, the CPU must activate and deactivate individual DMA channels while executing interrupt routines. Because of the 8237's bit set/reset capability, its control registers can set or clear one DMA channel without affecting or even knowing the state of the other three channels. It is sufficient to specify the channel and whether to activate or deactivate. This feature is valuable also when a common routine is used to interface the DMA controler.

Another application for the DMA is in intelligent terminals, to control data flow to an 8275 CRT controller and to handle high-speed data transfers to and from a floppy-disk 8271 controller (Fig. 2). (In the latter task, the DMA uses just two channels; the two remaining channels of the 8237 can provide memory-to-memory block transfer to help the CPU manipulate the disk and CRT data.)

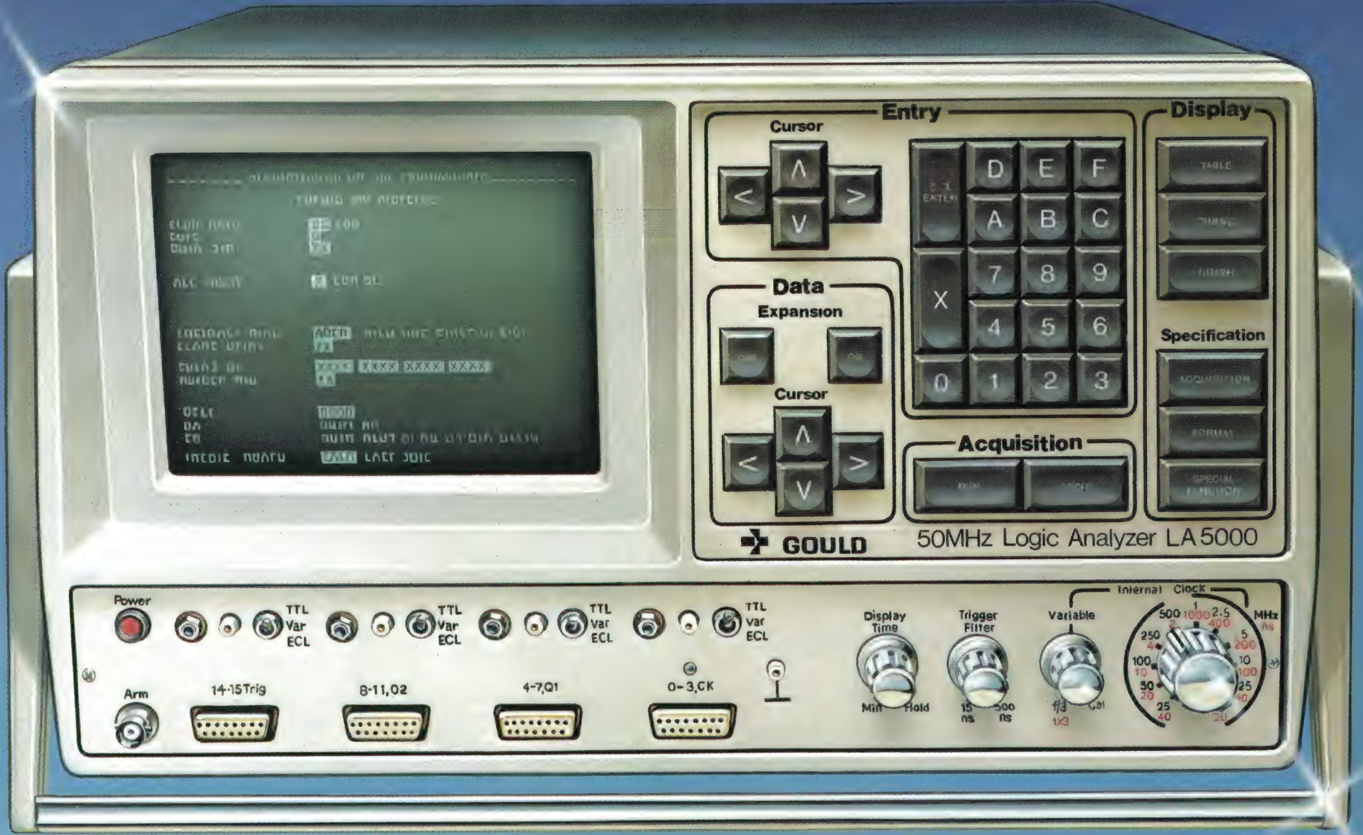
Disk scanned for byte sequence

During a CRT refresh, the CPU may request the disk controller to scan the disk for the first occurrence of a given byte sequence. The disk controller can repeatedly compare each sector of the disk with the one segment of memory, but CPU intervention is unnecessary because of the 8237's auto-initialization feature. The 8237 automatically reinitializes its pointers to the beginning of the compare sequence for each sector of the disk.

The 8237 also has a so-called fill capability that is especially valuable in CRT applications—it blanks CRT displays by filling the associated RAM space with blanks. Blanks in channel 0 of the DMA controller can be moved into any number of subsequent locations on channel 1. With this feature, the 8237 can also clear main memory or fill the CRT with a special character other than a blank.■■

How useful?	**Circle No.**
Immediate design application	**547**
Within the next year	**548**
Not applicable	**549**

MICROPROCESSOR GLITCHES: MEET YOUR FIXER.



Biomation's new LA-5000 50MHz logic analyzer brings the convenience of our K100-D to microprocessor designers.

Following our K100-D, which sets the industry standards for digital system debugging, Biomation brings you a new glitch fixer, the LA-5000. A logic analyzer matched in cost and capability to the needs of microprocessor system designers.

The LA-5000 is ideal for data domain and timing analysis with clock rates from 12.5 MHz with 16 recording channels, to 50 MHz with 4 channels. Three display modes give you: data domain information in binary, octal or hexadecimal; timing diagrams; even a graphic plot of successive word values.

Three full screen interactive menus—Acquisition, Format, and Special Function—make set-up fast and simple. There are also partial menus of frequently needed parameters as part of the display modes.

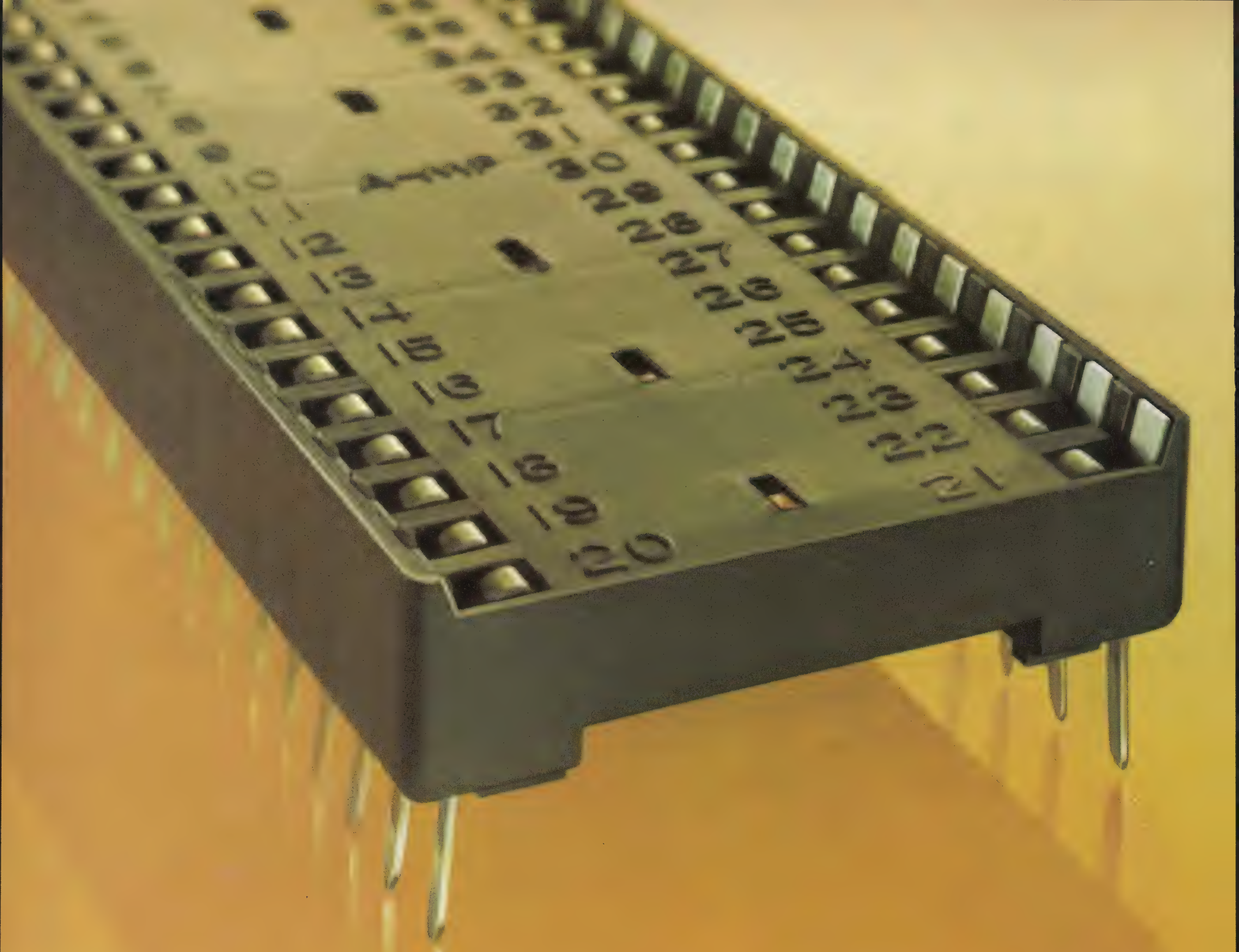
Convenience features? The LA-5000 features two memories with an auto-stop function to simplify fault-finding. Reverse video highlighting calls attention to memory differences. The reference memory is easily accessible via the keyboard. And, a memory search feature matches like sequences in both working and reference memories.

Introduce the glitches plaguing your system to their fixer. You'll enjoy efficient system debugging at a price well below what you'd expect to pay. For more information on the LA-5000, or any of Gould's full line of logic analyzers, write:

Gould Instrument Division,
Santa Clara Operations,
4600 Old Ironsides Drive,
Santa Clara, CA 95050.
Or call (408) 988-6800.

GOULD
An Electrical/Electronics Company

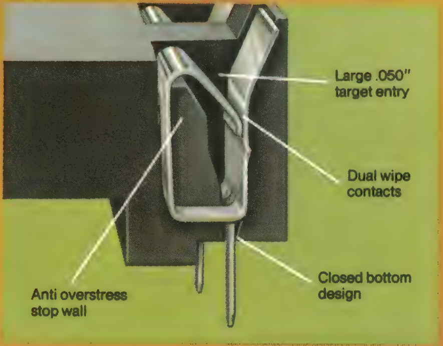
CIRCLE NUMBER 42



"For engineers who want all

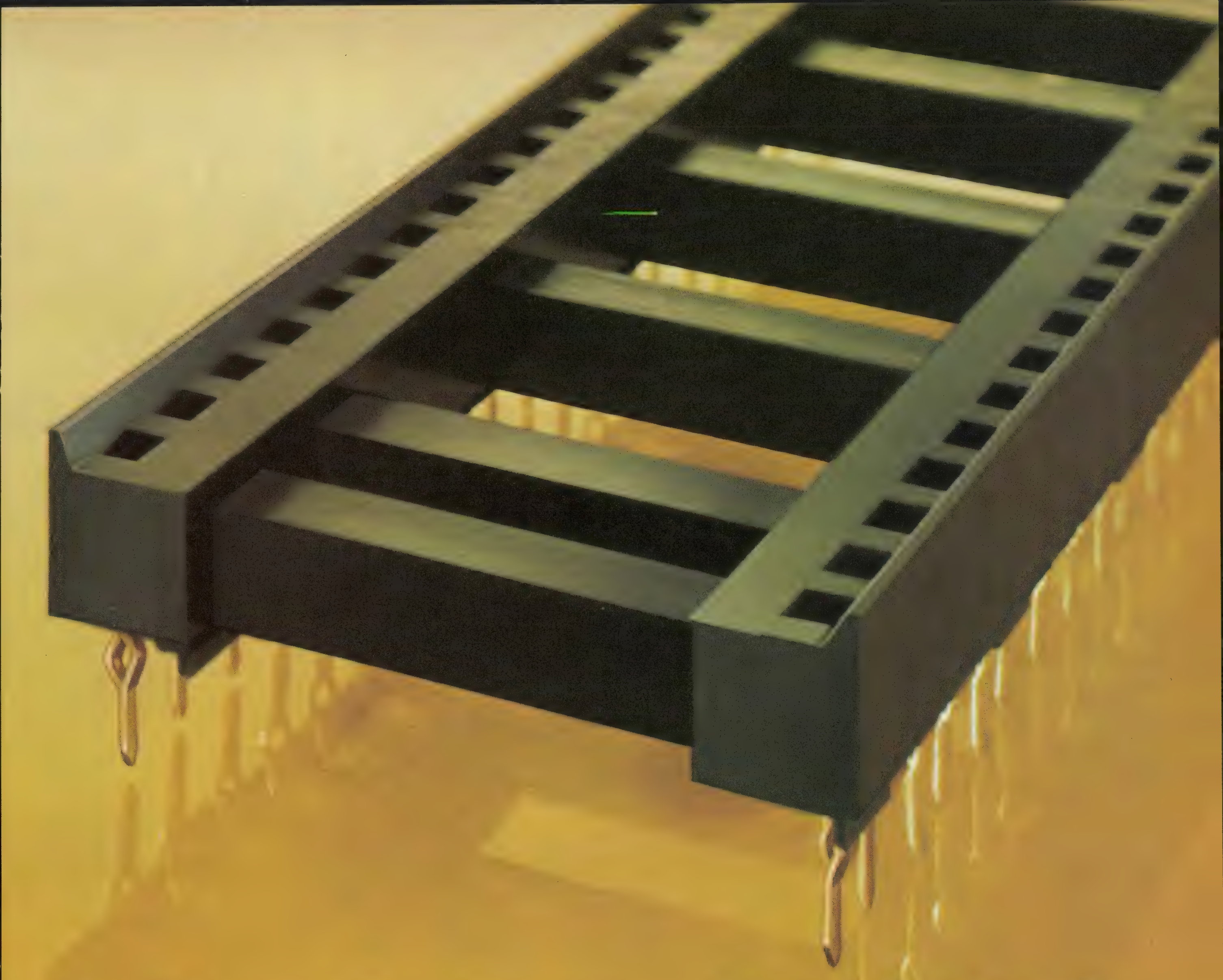
AMP DIPLOMATE 175 Sockets feature:

- 8 to 40 position sizes
- reliable interconnect in tin or select-gold plate
- large entry target area
- dual wipe contacts
- internal contact anti-overstress stop wall
- closed bottom design
- compatibility with automatic insertion equipment
- immediate delivery via a computer-linked regional inventory system

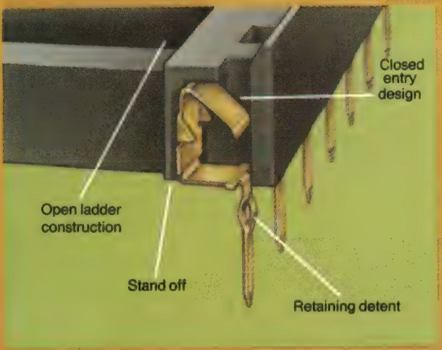


For the delivery details or for more information, call the DIPLOMATE .175" Profile Socket Information Desk at (717) 780-8400. Or write us. AMP Incorporated, Harrisburg, PA 17105.

AMP & DIPLOMATE are trademarks of AMP Incorporated.



the best features-plus choice."



AMP 160 Sockets feature:

- 8 to 44 position sizes
- lowest economical profile available (.160 ins.)
- anti-wicking, anti-bridging contact design
- ladder housing construction
- tin or select-gold plated contacts
- single row versions for packages with non-standard spacings
- qualification to MIL-S 83734

For the delivery details or for more information, call the AMP .160" Profile Socket Information Desk at (717) 780-8400. Or write us. AMP Incorporated, Harrisburg, PA 17105.

AMP has a better way.

AMP

CIRCLE NUMBER 43

THREE STEPS TO REDUCE PACKAGING COSTS WITH POLYMER THICK FILM.

PTF can be screened on practically any insulating material. Conductors, resistors and crossover insulation are processed in multiple with techniques similiar to those employed in the PC industry. This permits repeatability on each large array, reduced handling costs and practically eliminates discrete fixed or variable resistors.

Methode has the certified test facilities, PTF pastes, PC or substrate production lines, plus all the know-how to help you finalize your design and expand your concept to volume production.

We have already saved customers thousands of design and production dollars in these areas: Under-the-hood automotive, military vehicles, medical electronics, home entertainment, consumer products, environmental controls, information displays, communication circuits, electronic toys, membrane keyboards, test instruments, etc.

Next step. . .circle the reader service number to get things started.

Only from . . .

Methode Development Co.

7447 W. Wilson Avenue
Chicago, IL 60656
(312) 867-9600

Circle 129 on Reader-Service Card

Speed-up, simplify IEEE-488 system-peripheral interfaces with a bipolar talker/listener

Getting the most out of an IEEE-488 bus system means data rates must approach 1 Mbyte/s. Of all the LSI intended for the talker and listener functions of the bus, only the 96LS488 bipolar interface circuit provides enough speed for maximum throughput. What's more, it simplifies the interface between a system controller and an instrument or other device connected to the bus. Not only does the 96LS488 provide all the necessary interface logic on a single chip but, being bipolar, it can drive the maximum load specified for the bus—48 mA per line—without the external buffers required by most other IEEE-488 interface circuits.

Housed in a 48-pin package, the 96LS488 operates from a 5-V supply, includes the complete source and acceptor handshake logic, provides separate talk and listen addresses and a secondary address capability, can do parallel and serial polling, and packs many other features that suit it to minimal chip-count systems.

Working with a bus controller, the bipolar circuit meets all the requirements of the IEEE-488-1978 (GPIB) standard, which provides mechanical, electrical and functional specifications for the byte-serial transmission of data and control signals over a bus.

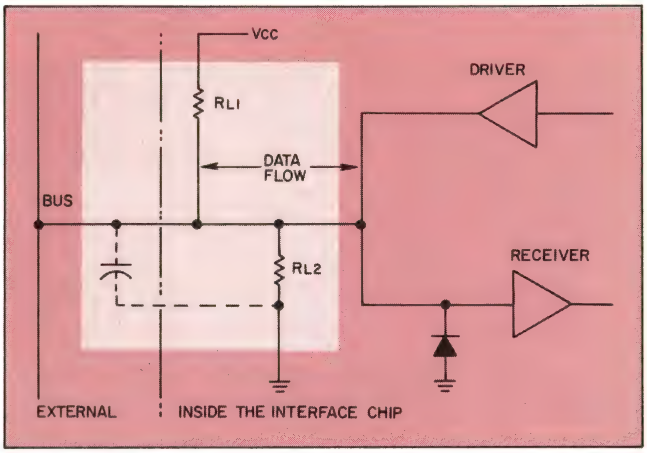
About the bus

The mechanical concept of the bus permits system elements to be connected in a star or linear (daisy-chain) arrangement, or a combination of the two. An individual interconnection cable can be as long as 4 meters and have plug and receptacle connectors on both ends (typically set up in one molded housing so that cables can be piggybacked). All connectors have 24 pins, with 16 lines used for signals and seven for signal grounds. The 24th line is for a shield ground, which is connected to the frame of each instrument to minimize noise susceptibility and danger to users.

Signal and ground conductors are limited to a maximum resistance of 0.14 Ω per meter, except for the common logic ground, which is limited to 0.085 Ω/m. To minimize crosstalk, the eight wires used for handshaking and control either should be twisted with ground lines or should use an equivalent isolation scheme. Although the standard does not limit the number of conductors in the cable, 16 twisted pairs have been found adequate. In addition, the capacitance (measured at 1 kHz) between any signal line and all other lines should be no more than 150 pF/m.

With an equivalent standard load for every 2 m of cable, the data rate can be 250 kbytes/s over distances of 20 m using open-collector drivers. If three-state drivers are used, the data rate can increase to 500 kbytes/s.

For 1 Mbyte/s, however, cabling can be up to 15 m long, with at least one standard load per meter of cable. At this rate, three-state drivers should be used, and the capacitance of each instrument on each line must be limited to at most 50 pF.



1. Inside the GPIB interface circuit, divider resistors help set the quiescent, high logic levels on the signal lines.

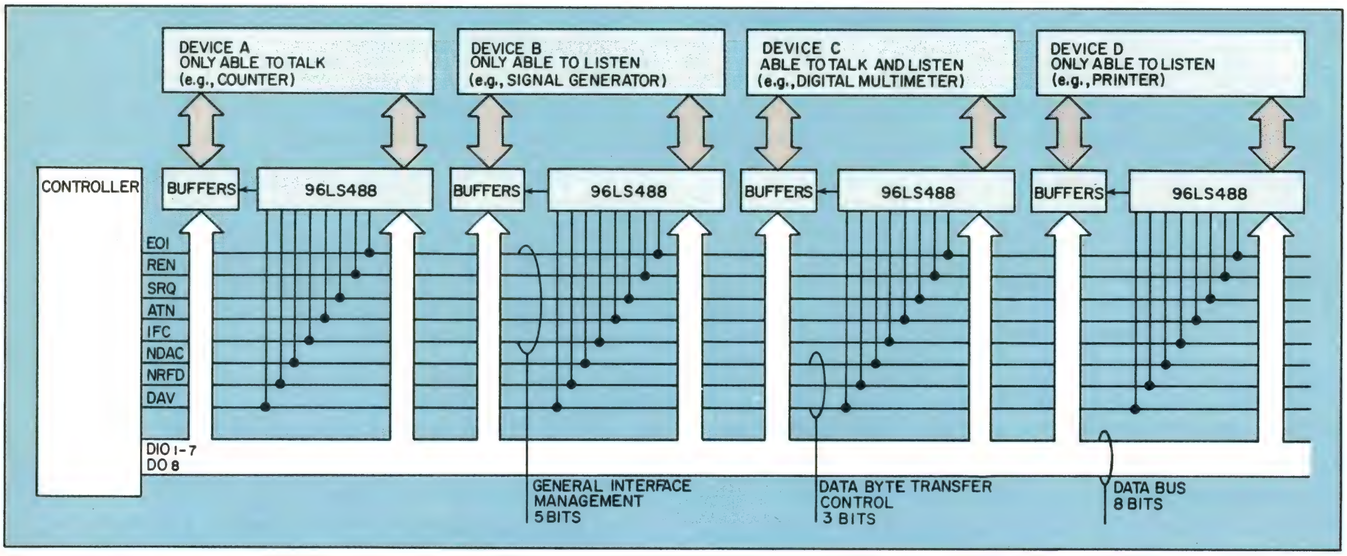
Charles Alford, Digital Applications Manager, Fairchild Camera and Instrument, 464 Ellis St., Mountain View, CA 94042.

Interface electrical specifications are patterned after TTL levels, but with a resistive divider added, as shown in Fig. 1. Establishing the high-state levels as the Thevenin equivalent of 2 kΩ returned to 3.4 V, it presents a −1.5-mA load at 0.4 V and supplies the charging current not available from an open-collector driver.

Each instrument or system element connected to the bus must contain this network for each signal line, whether or not a driver or receiver is connected. Thus, in a system with an average of one instrument every 2 m of cable, the resistive dividers alone can charge a maximum-capacitance line from 0.4 to 2 V in about 0.6 μs after an open-collector driver is turned off.

Low and high logic levels are specified as 0.8 and 2 V, respectively, and Schmitt-trigger inputs with a 0.4-V hysteresis are recommended. The receiver's input low current is limited to −1.6 mA, maximum, while the limit for the receiver and divider combination is −1.3 mA, minimum, and −3.2 mA, max, at 0.4 V.

Driver outputs must be able to sink 48 mA at a



2. In a typical system using the GPIB interface, a controller initiates events, monitors the system, and issues instructions to control the multiple interface circuits and instruments connected to the bus.

Table 1. Operating-mode options

Mode inputs				Operating mode	Function
M_0	M_1	M_2	M_3		
0	0	0	0	Off-line	The device cannot take part in any GPIB operations
0	0	0	1	TON (low-speed)[1]	The device goes directly to the talk-addressed state and can source data to the bus
0	0	1	0	LON	The device goes directly to the listen-addressed state and can receive data from the bus
0	0	1	1	TON (high-speed)[1]	Same as for TON (low-speed)
0	1	0	0	T (low-speed)[1]	Talker only, single-address mode
0	1	0	1	TE (low-speed)[1]	Talker only, extended-address mode
0	1	1	0	T (high-speed)[1]	Talker only, single-address mode
0	1	1	1	TE (high-speed)[1]	Talker only, extended-address mode
1	0	0	0	L	Listener only, single-address mode
1	0	0	1	LE	Listener only, extended-address mode
1	0	1	0	L	Listener only, single-address mode
1	0	1	1	LE	Listener only, extended-address mode
1	1	0	0	T/L (low-speed)[1,2]	Talker/listener, dual-address mode
1	1	0	1	TE/LE (low-speed)[1]	Talker/listener, dual-address mode
1	1	1	0	T/L (high-speed)[1,2]	Talker/listener, dual-address mode
1	1	1	1	TE/LE (high-speed)[1]	Talker/listener, dual-address mode

1. The low-speed talker option is selected where open-collector data drivers are used. The delay from putting valid data on the GPIB to DAV going true is 2 μs. The high-speed option is selected where three-state drivers are used. The setting delay (data to DAV) is 1.1 μs for the first byte sent after a low-to-high transition of ATN and 500 ns for subsequent bytes.
2. For single-address talker/listener modes, the talk and listen addresses can be different.

maximum low output level of 0.5 V. For a three-state driver, the output high levels are 2.4 V when sourcing 5.2 mA. A resistive divider determines the high level for an open collector driver at 2.5 V, min, and 3.7 V, max.

When an instrument is powered off, the resistive divider tends to degrade the V_{OH} level of the signal line. To provide for this, the standard advises that the system will operate properly as long as the quiescent V_{OH} level of each signal line meets the 2.5-V minimium requirement. The one exception, though, is for the maximum data-transfer rate—all instruments must be powered-on to minimize degradation of any signals.

Understand the control requirements

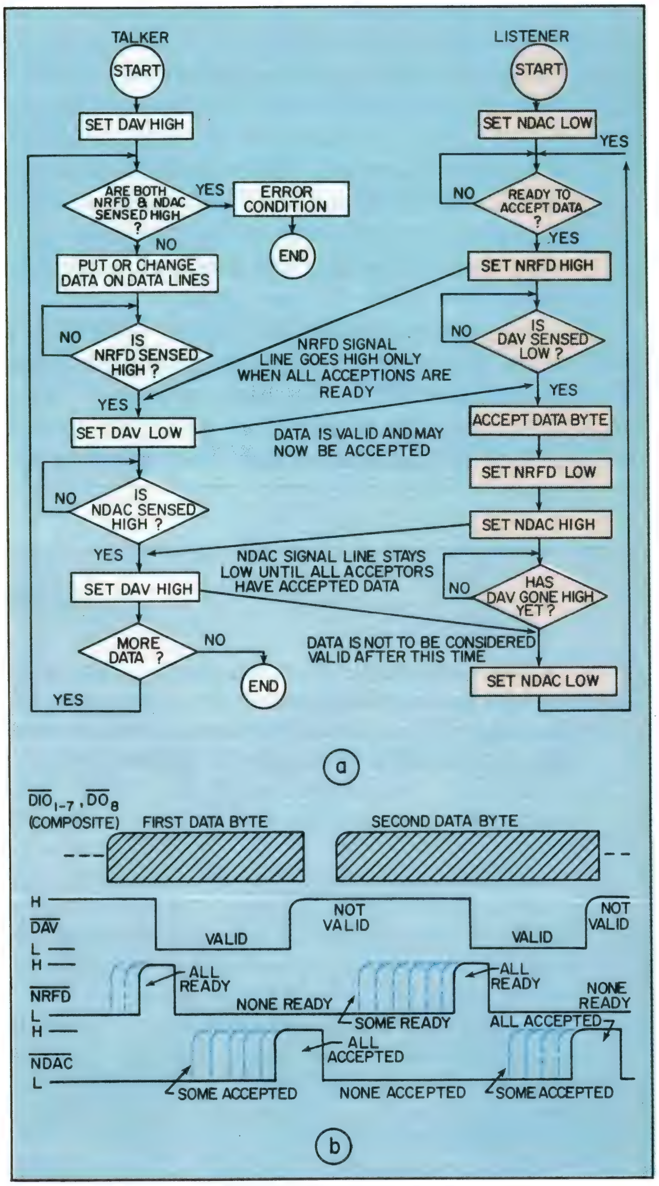
The third part of the GPIB standard defines a set of control functions, instructions and sequences designed to provide the unambiguous flow of information between the various interconnected elements in a system. While specifying the necessary messages to manage the interface system itself (called interface messages), the standard does not specify device-dependent message content.

The bus's 16 signal lines are divided into two groups of eight (Fig. 2). The first eight ($\overline{\mathrm{DIO}_1}$ through $\overline{\mathrm{DIO}_7}$ and $\overline{\mathrm{DO}_8}$) transfer data and other messages in a byte-serial, bit-parallel sequence. The second eight provide the control signals and handshaking necessary for transferring data asynchronously on the bus.

Of the control group, Data Valid ($\overline{\mathrm{DAV}}$), Not Ready for Data ($\overline{\mathrm{NRFD}}$) and Data Not Accepted ($\overline{\mathrm{NDAC}}$) operate in an interlocked handshake sequence to coordinate the asynchronous data transfer. General interface management is provided by the other five lines:

- Attention ($\overline{\mathrm{ATN}}$). Driven only by the controller, this line can be forced low to compel all instruments or system elements to relinquish control of the interface lines within 200 ns and listen to the data lines.
- Interface Clear ($\overline{\mathrm{IFC}}$). Driven only by the controller, this line can go low to force all instruments to a known quiescent state—the provision for initializing the system.
- End Or Identify ($\overline{\mathrm{EOI}}$). This line is used by either a talker to signify the end of a multibyte message or by the controller as part of a parallel-poll sequence.
- Service Request ($\overline{\mathrm{SRQ}}$). When the line is pulled low by any system element to get the controller's attention, the controller responds at its discretion by conducting a serial or parallel poll to identify the requesting device or devices.
- Remote Enable ($\overline{\mathrm{REN}}$). Driven only by the controller, this line is forced low to transfer control of each instrument's functions from the instrument front panel to the interface bus.

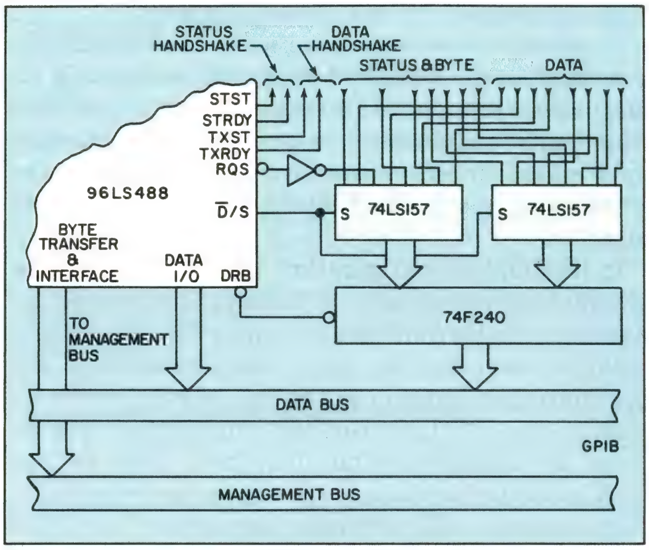
The sequence of signals on the $\overline{\mathrm{DAV}}$, $\overline{\mathrm{NRFD}}$ and $\overline{\mathrm{NDAC}}$ lines during the asynchronous transfer is described



3. Source and acceptor (talker and listener) handshake logic contained in the 96LS488 follows the flow chart (shown here) to implement the IEEE-488 communications protocol (a). The timing diagram for one talker and multiple listeners on the GPIB (b) shows the sequence of signals on the three handshaking lines during an asynchronous data transfer.

Table 2. Status-code outputs

$\overline{TAD}$	$\overline{LAD}$	$\overline{D}/S$	State
0	0	X	Off-line
0	1	X	Addressed to listen (LAD)
1	0	0	Addressed to talk (TAD)
1	0	1	Serial-poll mode (SPM)



6. When an instrument must provide status information to the controller or another unit connected to the bus, the $\overline{D}$/S output of the 96LS488 can control external multiplexers to select data or status as the source to the bus drivers.

ment is requested to return a status byte, via the usual handshake, to the controller. Seven bits are defined by the instrument. Bit 7, denoting Request Service Status, is provided by the 96LS488 on its $\overline{RQS}$ output line. If the instrument provides no status but $\overline{RQS}$, the $\overline{RQS}$ output can drive the bus directly. However, if the instrument provides status information, this information can be multiplexed onto the bus using the $\overline{D}$/S line, as shown in Fig. 6.▪▪

For a detailed explanation of the controller and other interface functions, send for Standard Digital Interface for Programmable Instrumentation *(IEEE-Std-488-1978), Institute of Electrical and Electronics Engineers, 345 E. 47 St., New York, NY 10017.*

Acknowledgment

The author wishes to thank Jon Summers, Design Engineer, Fairchild Design Center in Bristol, England, and Steve Goodspeed, Design Manager, Digital Products Div., in South Portland, ME, for their technical contributions.

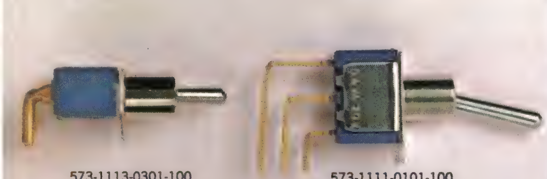
How useful?	**Circle No.**
Immediate design application	**550**
Within the next year	**551**
Not applicable	**552**

Dialight rockers & toggles

ROCKER AND TOGGLE SWITCHES FOR ALL APPLICATIONS

Contact Rating Information
1. Low Level: 0.4 Volt Amps Max @ 20 VAC or DC.
2. Standard: 5 Amps @ 120 VAC and 28 VDC, or 2 Amps @ 250 VAC.
3. Standard/Low Level Combination: 5 Amps @ 120 VAC/28 VDC, 0.4 VA Max. @ 20 VAC or DC.

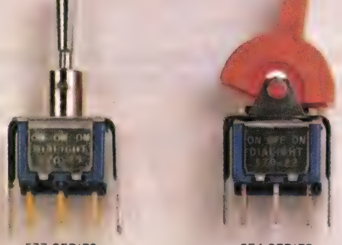
573 SERIES PC MOUNTED TOGGLE SWITCHES



573-1113-0301-100 (horizontal)
573-1111-0101-100 (vertical)

PC Mounted Toggle Switches Easy to mount . . . terminals bent at a 90° angle. Available with and without epoxy sealing . . . and with 7 types of actuators available for low, standard or low/standard levels . . . Low cost . . . Fast delivery.

PC MOUNTED ROCKER/TOGGLE SWITCHES WITH SUPPORT BRACKETS



577 SERIES
574 SERIES

Support brackets take strain off the PC terminals . . . various types available . . . Available in all toggle, rocker and lever actuators. Available in low, standard or low/standard level ratings . . . all these variations competitively priced.

Dialight meets your needs. So talk to the specialists at Dialight, first. Send for your free copy of Dialight's current catalog today.

DIALIGHT

Dialight, A North American Philips Company
203 Harrison Place, Brooklyn, N. Y. 11237
(212) 497-7600

CIRCLE NUMBER 44

From the graphics leader.

Our design-size desktop computer. Precise. Productive. Interactive graphics. **Precision for details like yours.**

The Tektronix 4054 desktop graphic computer is perfect for the big, intricate, fine-line demands of electronics design. It features a 19-inch version of our exclusive, high-resolution display technology. The 4096 x 3125 resolution provides over 13 million addressable points, so it can deliver the large scale and minute detail you're looking for.

16-bit processor leverage. With 32K bytes of memory, expandable, and computational capabilities far beyond the scope of most desktop computers, you can do more analysis. Get more results. Get all the advantages of a system built for graphics.

Desktop convenience and graphic interactivity. You can include a Dynamic Graphics option that lets you create, position and assemble complex designs, without time-consuming erasures or corrections. Results come easy with our graphically-enhanced BASIC software and a wealth of applications assistance in our PLOT 50 library. You can choose from a full complement of Tektronix peripherals including mass storage devices, graphic tablets and digital plotters.

Draw your own conclusions. For a desktop demonstration call, toll-free, 1-800-547-1512. In Oregon, 644-9051 collect. Or write:

Tektronix, Inc.
Information Display Division
P.O. Box 500
Beaverton, OR 97077

Copyright © 1979 Tektronix, Inc. All rights reserved.
OEM information available on request.

Tektronix®
COMMITTED TO EXCELLENCE

CIRCLE NUMBER 46

Technology. Product. Performance. Price. They got us there. They'll keep us there. The first family of control and interface circuits. From the linear leader. Texas Instruments.

Leadership doesn't come easy. In any industry. It has to be earned. Over the years, TI's innovative, high-performance, low-cost, readily available linear control and interface circuits have become the industry standard for excellence. For reliability. For availability. For everything from commercial, industrial and military, to the most demanding aerospace applications, TI's broad linear line is doing the job.

So, whatever your functional design process requirements, whether it's op amps or comparators, voltage regulators or data acquisition devices, line drivers or receivers, peripheral or display drivers, or innovative special function ICs — Texas Instruments is your linear super source.

For the state-of-the-art today. And tomorrow.

Control Circuits

Operational amplifiers

In addition to a full line of conventional op amps, TI brings you BIFET. The new standard in op amps. And TI offers the broadest BIFET line. In fact, TI is the only manufacturer to offer three complete BIFET families. Three families. Each with singles, duals and quads. Each production-proven for more than 2 years now. Each offering the best of BIFET cost/performance effectiveness. Low price. Low offset. Low noise. Low power. The TL081 Series is our general purpose family. TL071 Series features low noise — and the TL061 Series is ideal for all low power dissipation applications.

Voltage comparators

TI offers a wide selection of single, dual and quad devices, with or without strobe. Comparators with FET inputs. Single and dual supplies. TI comparators feature fast response times, improved gains and accuracy, low offsets — and, of course, low prices.

Voltage regulators

Whatever your power supply design requirements, TI's broad line of voltage regulators makes it easy. If simple, destruct-proof circuitry is your goal, choose from the popular 78/79 Series, 3-terminal fixed voltage regulators, available in a variety of output voltages in positive and negative selections, 100 mA to 1.5 amp ranges.

If versatility is important, TI offers both series and shunt 3-terminal adjustable voltage regulators. The 317 Series offers full overload protection and improved I/O regulation. Both TL430 and TL431 feature improved temperature compensation and programmable shunt voltage ranges from 3 to 30 V. At a fraction of compensated Zener costs.

Any one of TI's family of switching regulator control circuits (TL497, SG3524, TL494) will satisfy even your most stringent efficiency requirements. TL497A is a fixed ON time circuit ideal for dc-dc conversion applications.

For transformer-coupled applications, the SG3524 and improved TL494 fixed frequency PWM controllers are also available.

Data acquisition

TI brings you exceptional strength in all the technologies associated with the fast-growing field of data acquisition — not merely in converters. Devices which are state-of-the-art today — and beyond that — the building blocks for tomorrow. Products designed to offer you greater accuracy, to operate at higher speeds and sell for lower costs. For efficient A/D conversion. For effective microprocessor interconnect. For optimum performance. All on a monolithic chip. The future of data acquisition is here now. And TI is intent on helping you make it work. At a price you can afford.

Interface Circuits

Line drivers/receivers

TI, the world leader in line circuits, with an ever-increasing repertoire of products, offers you a wide choice of drivers, receivers and transceivers for virtually all data communications applications. Included are line circuits that meet all industry standards: EIA RS232C, RS422, RS423 and IEEE interface standard 488. A full line of general purpose line drivers with TTL compatible inputs and 3-state outputs are also available. Single-ended and dual-differential, 5-V power supply, plus party line operation, too. An example of this is TI's recently introduced IEEE 488 octal transceivers. One for data bus. One for management bus. They help reduce system power and board space by 40%.

TI's newest line driver circuits feature low-standby power drain and improved drive characteristics.

Peripheral drivers

Including industry leaders SN75460 and ULN2064 Series. With a spread of 300mA-3A and 15-100 V, you have the highest output power available. Single package, monolithic devices, TI peripheral drivers save assembly time, improve reliability, cut component costs. No problem driving inductive loads, either. And, all the logic is on-the-chip. Availability, excellent. Prices, competitive.

Display drivers

A wide range of display drivers to satisfy all the leading visual display technologies, like plasma and VF. Other drivers are available for use with 7-segment LEDs, gas discharge and thermal print displays. Offered in a variety of pinouts in ceramic or plastic packages in the commercial temperature ranges, TI's newest display drivers are being designed with on-chip "intelligence" — so, there's no need to refresh. All TI display drivers are system compatible with today's popular logic families and microprocessors.

Special Functions

Analog/Detector circuits, timers

Choose from a wide variety of special function ICs for specific applications, including: precision timers, analog switches, monolithic, twin, dual and twin-dual BI-MOS, each with TTL, MOS and CMOS compatibility. Also, analog level sensors, Hall effect devices, switches and linear sensors, zero voltage switches, log and differential video amplifiers and oscillators.

Full Line Linear Supplier

In addition to the full line of TI-originated products, we support you with all the popular industry standard linear products as a second source. So, more and more, TI is the company to come to. For all your linear needs. It's the super source in the marketplace. Today. And tomorrow.

As we continue to improve and upgrade existing products, reinforcing the TI learning curve principle — as we continue to recognize emerging markets and define new products — as we continue to move toward higher system level integration, and toward new technologies — our continuing commitment keeps on growing.

The Future of Linear

TI will keep meeting the ever-increasing demand of linear commitments. To the industry. And, with renewed emphasis, on factory and distributor support.

That's leadership. That's Texas Instruments.

For complete, detailed information on the industry's first family of linear circuits, fill out and return the coupon.

Texas Instruments Incorporated
P. O. Box 225012, M/S 308
Dallas, Texas 75265.

ED-2

Fifty Years of Innovation

Please send me information on:

- ☐ Op Amps
- ☐ Voltage Regulators
  - ☐ 3-Terminal
  - ☐ Switching
  - ☐ Adjustable
- ☐ Data Acquisition Devices
- ☐ Line Drivers/Receivers
- ☐ Peripheral Devices
- ☐ Display Drivers
- ☐ Special Function ICs
  - ☐ Analog Level Detectors
  - ☐ Hall Effect Switches
  - ☐ Analog Switches
  - ☐ Log Amplifier
  - ☐ Timers
  - ☐ Other ______

Name ______ Title ______

Company ______

Address ______

City ______ State ______ Zip ______

TEXAS INSTRUMENTS
INCORPORATED

© 1980 Texas Instruments Incorporated

One-chipper gives eight operating modes to the cause of optimum system design

The first article in this series on the MC6801, describing the basic features and operating characteristics of the chip, appeared in ELECTRONIC DESIGN *on Aug. 2, 1979, p. 76.*

Before completing any μC-system design with the MC6801, examine its eight operating modes. Selection of the right mode will help to optimize design efforts and minimize hardware. The operating mode will not only determine the system makeup, but much of the system interface as well. Each mode offers a different amount of:

- Internal memory
- I/O lines
- Address space
- Access to external memory
- Testing
- Internal or external control of program execution.

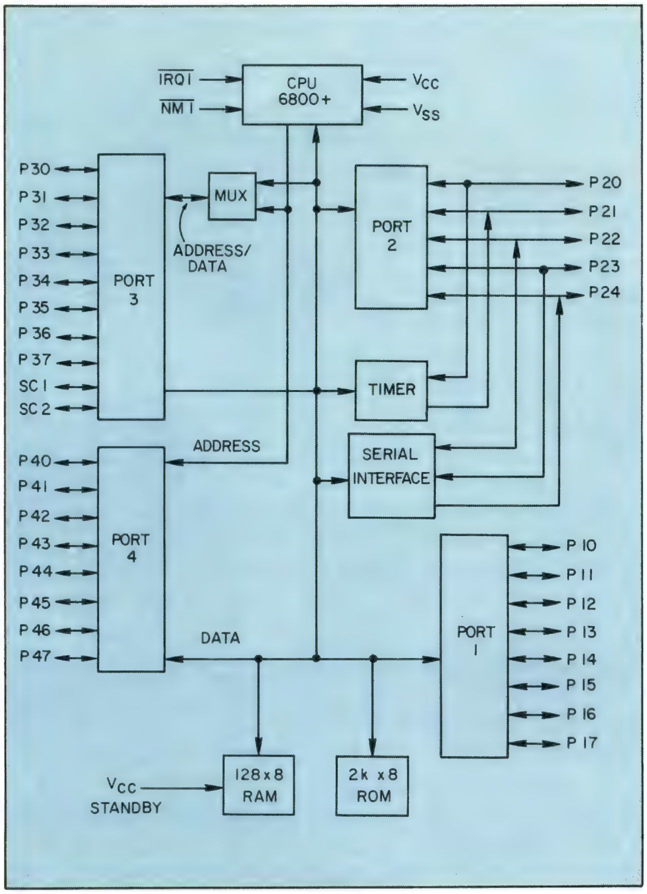
These features must be balanced against the expected needs of the system.

The MC6801 single-chip microcomputer combines all the elements a system designer needs on a single silicon chip (Fig. 1). An enhanced (yet machine-code compatible) 6800 CPU, 2048 bytes of ROM, 128 byes of RAM, 29 I/O lines (including a counter/timer and a full-duplex serial port) and an on-chip clock oscillator permit the 6801 to operate in a stand-alone mode or to be expanded easily by the other modes available (see table).

In general, the single-chip, stand-alone mode (Mode 7) costs a few more development dollars but reduces system costs through reduced component count, smaller board area and better reliability. However, when the program memory must exceed 2048 words, the Mode 7 solution is unusable. Several of the other operating modes allow longer programs because the CPU can address additional external memory.

To address external memory, the 6801 must give up some of the features available in its stand-alone mode. Fig. 2 shows some of the expansion possible from the single-chip mode to two other modes, depending on the additional memory requirements. (The method of switching between operating modes is described in "Set the Operating Mode Like This.")

The limitations of these modes are not in program memory capacity, but in other performance characteristics. For example, the system shown in Fig. 3a (Mode 5) collects and maintains data in excess of the 128 words of RAM contained on the 6801. Mode 5 (the expanded nonmultiplexed mode) and Mode 6 (the expanded multiplexed mode) both permit data to be



1. With four programmable ports as well as an enhanced 6800 CPU, the MC6801 processor can hold programs that are up to 2048 bytes long and provides a scratchpad RAM that can store 128 bytes.

Clint Bauer, Automotive Systems Engineer, Motorola Inc., Semiconductor Group, 2200 W. Broadway, Mesa, AZ 85202.

stored in outside RAM, but they meet different memory requirements, as shown in Fig. 3a and b. As an added benefit, other processors or peripherals could share the external data RAM using the scheme shown in Fig. 3c. This technique can be implemented easily, since the 6801 accesses external memory only when the E line is high; external hardware can then access the RAM when E is low.

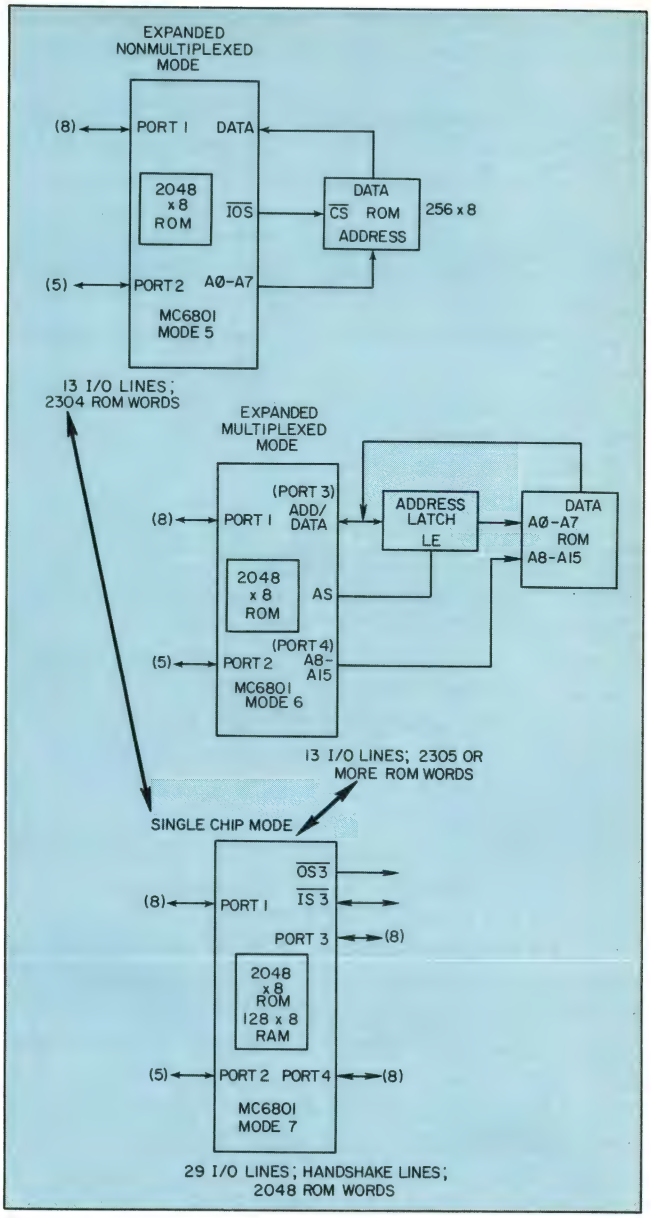
Sometimes memory requirements can be satisfied entirely on-chip, but the application might not be served as well by the single-chip Mode 7. Automobile control systems are a good example. Different car lines and even different models of the same line might need external ROMs or PROMs that would provide initial, individual, set-up data for the general program built into the processor. The final decision is based on economics—the cost of relatively expensive control modules, compared to the cost for one general-purpose module and a number of inexpensive "signature" PROMs to customize the module for a particular car.

External signature ROMs provide a handy way to "customize" the general program stored in the processor. However, since the memory is external to the chip, access is much slower than for on-chip memory. To speed up access, one technique, loads the signature ROM into the internal RAM upon system initialization. This action puts all the data on-chip and minimizes access delays. After the ROM contents are loaded into the RAM, the I/O ports are freed to return to their intended purpose.

Select the mode for top performance

The basic design questions for any application are: Should the performance of the system be adjusted to meet the performance limitations of the chip; or should the chip be used in its multiple-chip mode to provide for maximum system capability? Should alternative systems be designed so that the one which performs best can be chosen?

Selection of the proper operating mode will cut down



2. The single-chip operating mode is expanded through the use of either the expanded nonmultiplexed mode or the expanded multiplexed modes. However, both modes tie up port lines that would otherwise be used for I/O lines.

Mode and port functions of the MC6801

Mode	PORT 1 Eight lines	PORT 2 Five lines	PORT 3 Eight lines	PORT 4 Eight lines	SC1	SC2
Single-chip (Modes, 4, 7)	I/O	I/O	I/O	I/O	$\overline{IS3}$(I)	$\overline{OS3}$(O)
Expanded MUX (Modes 0, 1, 2, 3, 6)	I/O	I/O	Address bus (A0-A7) Data bus (D0-D7)	Address bus* (A8-A15)	AS(O)	R/$\overline{W}$(O)
Expanded non-MUX (Mode 5)	I/O	I/O	Data bus (D0-D7)	Address bus* (A0-A7)	$\overline{IOS}$(O)	R/$\overline{W}$(O)

*These lines can be substitued for I/O (input only) starting with the most significant address line:
I = Input
O = Output
R/$\overline{W}$ = Read/Write
IS = Input strobe
OS = Output strobe
IOS = I/O select
SC = Strobe control
AS = Address strobe

on the external hardware needed for a design and facilitate the compression of bulky firmware onto the on-chip ROM. The operating mode should fit both the expected constraints on the system and the capabilities built into the MC6801 chip. These capabilities change for each of the eight modes.

In Mode 7, the 6801 operates as either a stand-alone controller or as a slave processor. Mode 7 differs from the other modes because of the features offered through Ports 3 and 4. As a slave processor, the 6801 takes advantage of Port 3 to operate as a peripheral component to a master CPU. Coded commands received on Port 3 are interpreted and carried out, resulting in the control of lines on Ports 1, 2 and 4.

When the 6801 operates in the slave mode, it offers eight I/O lines intended for fast master/slave communication along with the use of the $\overline{\mathrm{IS}}_3$ and $\overline{\mathrm{OS}}_3$ control lines. However, for a full 8-bit bidirectional data flow, some software overhead is required to monitor and select the directionality of Port 3. If only 4 bits of I/O are needed in each direction, the overhead disappears.

When operated from an appropriate crystal or external timing source, the 6801 has available on pin 40 a square-wave signal at one-fourth the crystal or source frequency. All the ports can be software controlled as inputs or outputs. Port 4 is controlled by the register at location 0005 and is accessed by the processor at location 0007. When the processor is reset, the port is initialized to a high-impedance input state.

Port 3 has more flexibility. Two signal-control lines (in addition to the eight I/O lines) are associated with Port 3; line $\overline{\mathrm{SC1}}$ becomes $\overline{\mathrm{IS3}}$ in Mode 7 and line SC2 becomes $\overline{\mathrm{OS3}}$. Five external interrupt lines are also available in Mode 7: the NMI, with a nonmaskable edge trigger; the $\overline{\mathrm{IRQ1}}$, a level sensitive input; the timer input, with selectable edge trigger; the Serial In, active on data reception; and the $\overline{\mathrm{IS3}}$, acting as a negative-edge trigger. Always an input line, $\overline{\mathrm{IS3}}$ shares the normal $\overline{\mathrm{IRQ1}}$ vector at locations FFF8 and FFF9.

Set the operating mode like this...

The eight operating modes of the MC6801 are hardware controllable and operation of the processor can be switched back and forth between modes. When the operating mode is programmed, the Reset input is held low for at least three clock cycles. The voltage present at the first three pins of Port 2 (P20, 21 and 22) determine the mode in which the processor will function.

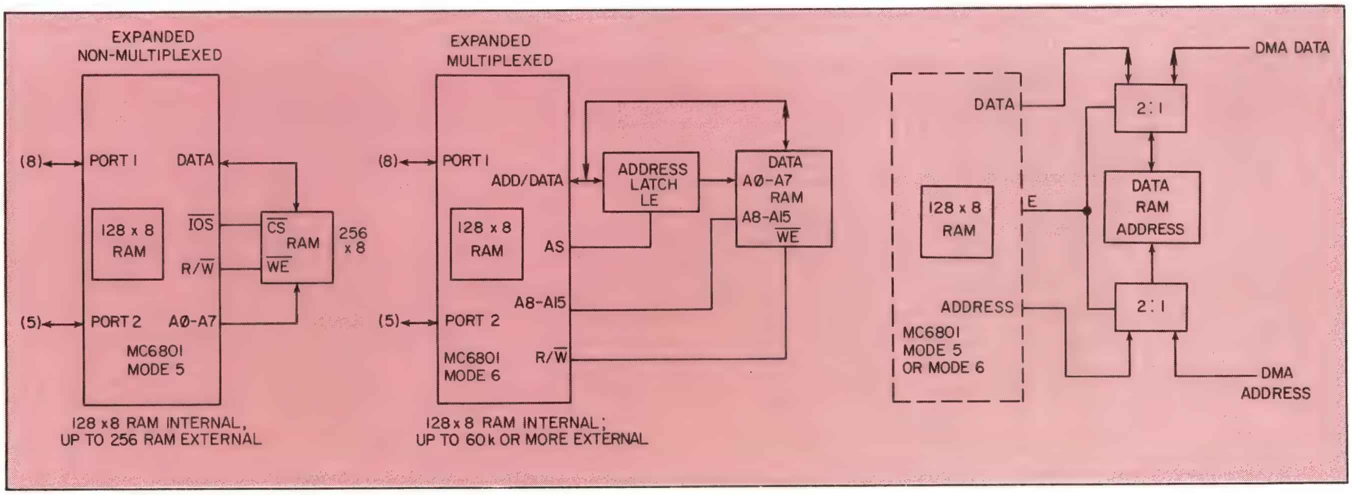
The states of the three pins are latched into the mode-control register when the Reset pin is brought high. The three most-significant bits of the register, which is located at address 0003 (hex), hold the mode-control data; the other five bits form the data register of Port 2.

Except when the mode is being selected, the mode control register is a read-only, and the operating mode cannot be changed by the processor. During Reset, however, the port lines are configured as inputs, and the mode control register is written to when the Reset line comes high.

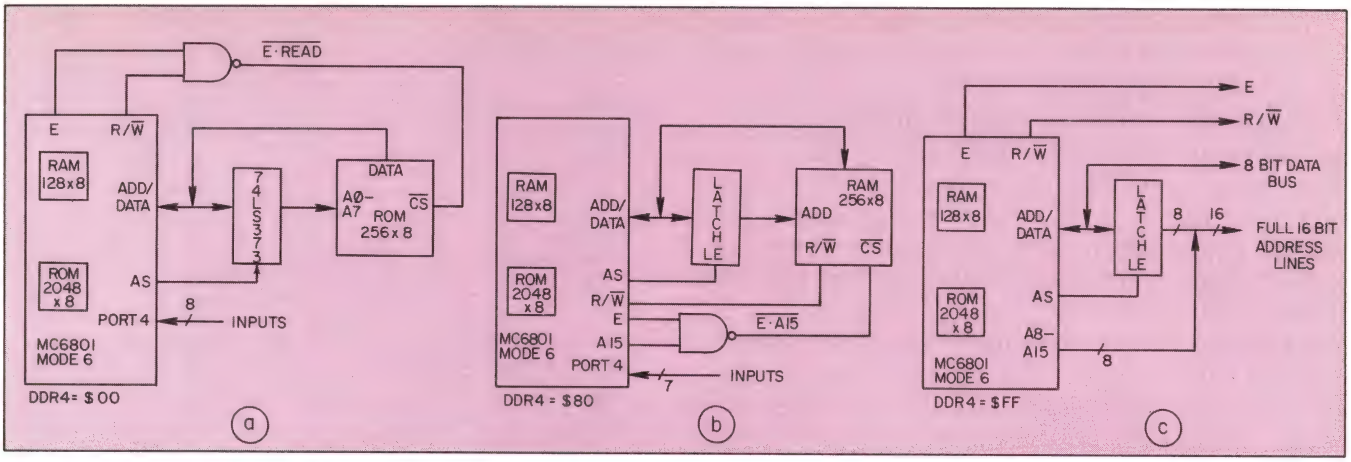
A diode connection or pull-up resistor can be used to set up the desired levels when the three port lines are to function as outputs. The diodes create a ZERO and the resistor creates a ONE.

	BIT 7							BIT 0
$F P3CSR	$\overline{\mathrm{IS3}}$ IRQ 1 FLAG	$\overline{\mathrm{IS3}}$ IRQ 1 ENABLE	X	OUTPUT STROBE SELECT (READ 6 / WRITE 6)	LATCH ENABLE (ALLOW/ $\overline{\mathrm{DENY}}$ LATCH)	X	X	X

4. Controlling the operation of Port 3, the control/status register contains four software-programmable lines that determine the operation of the interrupt input, the output stobe and the latch enable.



3. The expanded nonmultiplexed mode accesses up to 256 bytes of external memory (a). The expanded multiplexed mode multiplexes data and addresses on Port 3 and uses Port 4 for additional address lines, to access up to 64 kbytes of memory (b). For external RAM, a transparent DMA permits high-speed data transfer (c).



5. These typical schemes for system expansion are simple to implement, requiring just a gate and latch in most cases. Decode schemes are shown for a minimal ROM system (a), a minimal RAM system (b) and a full expansion of the memory system to 64 kbytes (c). Decoding of R/$\overline{\text{W}}$ or address partitioning is necesssary.

Mark and status bits are included in the P_3 control/status register (located at address 000F), which can be programmed for the desired operation of Port 3 and of the $\overline{\text{IS3}}$ and $\overline{\text{OS3}}$ lines (Fig. 4). All available bits in the register are processor controlled but cleared at processor reset.

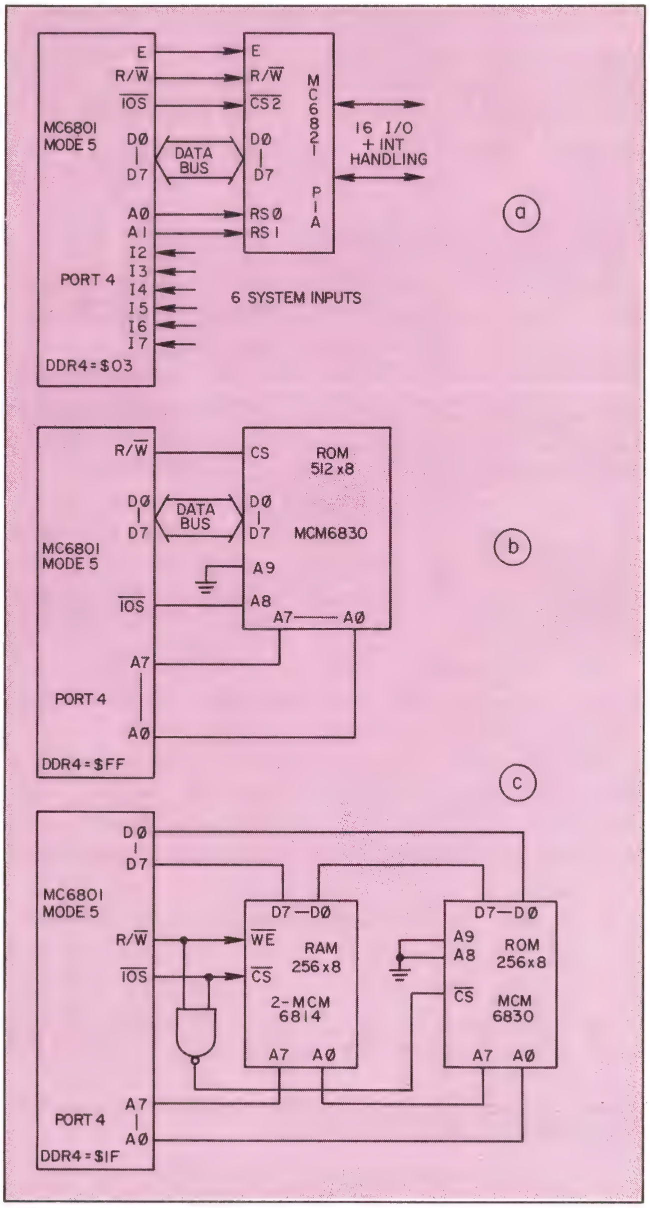
Port 3 has data accessible at 0006 and is controlled by the register at location 0004. The port inputs act normally when the Latch-Enable bit of the control register is low. However, when the bit is high, the port inputs are latched at the falling edge of the signal on the $\overline{\text{IS3}}$ pin.

The $\overline{\text{OS3}}$ output line stays high until Port 3 is written to or read from by the processor. Bit OSS in register 000F selects the read or write cycle to the Port 3 data register to activate $\overline{\text{OS3}}$. When activated, $\overline{\text{OS3}}$ falls for one clock cycle only, one cycle after the port was accessed.

Dual 6801 systems can communicate, processor-to-processor, through Port 3 lines if the $\overline{\text{IS3}}$ and $\overline{\text{OS3}}$ lines are cross-coupled. Ports 2 and 1 operate in a similar fashion to Ports 3 and 4 in most cases. However, Port 2 offers five I/O lines that can be programmed to provide the timer and serial I/O capability, while Port 1 offers direct Darlington drive capability on all eight available lines.

Go to Mode 6 for a large system

When the processor changes from the stand-alone or slave mode to an expanded multiplexed mode (Mode 6), its address space can grow to the full 64 kbytes but the number of I/O lines drops to 13 bidirectional lines. An intermediate addressing range can be selected to gain back some of the I/O lines. Also, the SC1 line of Port 3 takes on the function of address strobe, and the SC2 line functions as read/write control. Port 3 becomes multiplexed, permitting the additional addresses to be delivered when the E signal is low and data to flow when the E signal is high. Use of an external demultiplexing latch restores the separate address and data-bus functions.



6. The I/O capability of the MC6801, along with the memory, is expandable in Mode 5. The system shown in (a) provides additional I/O by means of a 6821; the system in (b) provides additional ROM space; and the system in (c) adds both RAM and ROM.

Port 4 takes up the slack for the other eight address lines as needed for the 64-kbyte space. The Port 4 lines are controlled by the bits in the control register, which can be written into at address 0005. When the bits in the register are set, the selected lines deliver address information to the external hardware. When all Port 4 lines are used to provide the other eight bits of the address, full access to the 64-kbyte memory space is possible, except where internal RAM, ROM or register access takes precedence.

Several methods to implement the expanded memory capacity are shown in Fig. 5. Write operations to the internal RAM or registers always start the external data-bus drivers. Therefore, R/$\overline{\text{W}}$ decode or address partitioning must be implemented. Internal read operations ignore the external data.

In a multiple-processor environment, Mode 6 gives the MC6801 multiple interrupt lines, to permit efficient software-cooperation for memory sharing or message handling. Multiple I/O lines select the proper data paths through bus interface hardware. The timer function can allocate time-sharing, thus eliminating the need for additional control hardware.

Small expansions require no extra parts

Similar to Mode 6, Mode 5 provides for memory expansion, but only up to 256 bytes, using 16 lines for address and data (Mode 6 uses eight lines). Mode 5 is a nonmultiplexed mode, so that Port 3 is not used when E is low but becomes the data bus when E is high. Port 4 provides the low-order address bits. To indicate that the processor is accessing the external 256 bytes of memory, the SC1 line becomes an I/O select signal ($\overline{\text{IOS}}$) that goes low each time the processor addresses any part of the memory in the 0100 to 01FF address range. The external memory is limited to 8 bits plus the IOS line.

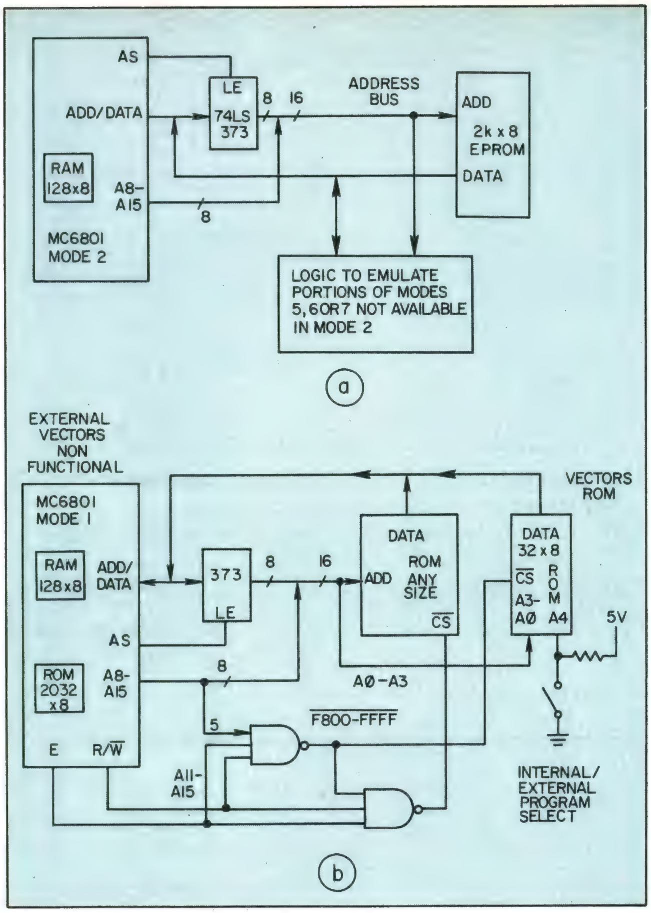
With this operating mode, an external latch is not needed. However as many as eight of the lowest address lines are selectable.

Line $\overline{\text{IOS}}$ is used to select external devices (Fig. 6a). When $\overline{\text{IOS}}$ is high, processor operation proceeds with the internal memory. The special implementations shown in Fig. 6b and c use less external logic than in Mode 6.

Thus, Mode 5 reduces the chip count for minimal expansion requirements; but for 256-byte external access, all Port 4 pins must be used as address outputs rather than as I/O. Any address lines that are not used are available as Port 4 inputs.

Test the chip with Mode 4

Next in the mode sequence, Mode 4 provides all Mode 7 pin functions and the internal RAM. However, the ROM is disabled and vectors are accessed from internal RAM. This mode permits Ports 3 and 4, and their associated control lines to be tested, since using up valuable ROM space for a test program in Mode 7 would not be economical.



7. In the emulation mode, the 6801 processor has all of its features active, except for the internal ROM, which is disabled (a). Using external hardware to provide new interrupt vectors, Mode 1 operation permits simple software modifications when internal ROM programs must be updated (b).

Mode 7 operation precludes the use of external memory, and the internal ROM and RAM is dedicated to the application program. On-chip test circuitry would add complexity to the already complex 6801. Mode 4 solves the test problems, and adds just a slight overhead onto the test equipment.

To use Mode 4, the processor is first placed in one of its expanded modes and code from an external source is loaded into the 6801's internal RAM. The processor is then reset in Mode 4. Now, the program already loaded into the RAM is executed to manipulate Port 3 and 4 lines and the related control lines.

Mode 4 is limited to 128 bytes of program storage for the RAM-based test program. If longer programs are needed they can be made modular and run out a section at a time.

After this portion of the test program runs, the processor can return to the nonexpanded operating mode (Mode 5) by writing to a special mode-control bit. The internal RAM contents can be read out through the serial data line while the 6801 is in either Mode 4 or 5. In Mode 5, testing could proceed using an external program. Mode 4 operation can be switched conveniently to Mode 5, but other modes are entered only when the 6801 is reset.

Other pins of the 6801 not functioning in Mode 7 can be tested in expanded Modes 0, 1, 2, and 3, since external ROMs can be connected in these Modes. Pin behavior in these modes is identical to that in Mode 6, except for pins 22 to 29, which were used as address/input lines in Mode 6. In Modes 0, 1, 2 and 3, these lines are address-only lines, and are always configured as outputs. Control register DDR4 is not available to select pin direction.

These modes also recognize certain normally-internal register addresses as external functions. When DDR3 and DDR4 (for Ports 3 and 4) and control/status register 000F (for Port 3) are read by the processor or written, data are recognized or appear at the external multiplexer bus. This feature is especially useful in Modes 2 and 3 (the emulation modes).

All the expanded modes activate the external data bus on any processor write operation, even when internal registers or RAM are accessed. Modes 5 and 6 take 0004, 0006, and 000F from the outside even though the Mode 5 line $\overline{\text{IOS}}$ is inactive at these addresses.

In Mode 3, the processor ignores the internal RAM and ROM together. However, internal registers are still responsive, permitting control of Ports 1 and 2. In Mode 2, the other emulator mode, the internal RAM returns into the picture. Programs can be developed with a minimal system, since an external EPROM containing an application program can be addressed instead of the internal ROM (Fig. 7a). Total end-product emulation can be achieved by the addition of external hardware.

Operation in Mode 1 provides most of the processor functions except for interrupt vectors, which are normally stored in the on-chip ROM. In Mode 1, these vectors are accesed externally. The external hardware selects when and where programs will be executed (Fig. 7b).

Finally, Mode 0 uses the entire internal RAM and ROM space, including vectors. Program execution, though, is still controlled externally by allowing the hardware reset line to suppress the initial access to the internal reset vector in favor of an externally supplied address. Program execution can be diverted to an external ROM, which may, for example, check the contents of the internal ROM.

Another version of the MC6801 processor, the MC68701 does not have internal ROM—it has an ultraviolet eraseable PROM instead. When this processor operates in Mode 0, it can execute code from external ROMs while the internal EPROM remains on line. The external program loads and manipulates data and then programs the internal EPROM, all under operator control. Thus, the MC68701 is self-programmable.■■

How useful?	**Circle No.**
Immediate design application	553
Within the next year	554
Not applicable	555

For:
Stability.
Repeatability.
Low Noise.
Linearity.
Accuracy.

It's EDC Model MV105J D.C. Voltage Standard for use in design and development labs as a reference, a source and a supply. It serves as a simulator for thermocouples and transducers. Production line quality control and field service calibration rely on this instrument as a dependable reference/standard.

Model MV105J's calibration accuracy is ± 0.003% of setting. You can't do better than that!

Two output ranges: ± 10 Vdc resolved to 10 μVdc and ± 100 mV resolved to ± 0.1 μVdc.

Line and Load Regulation is ± 0.0005%.

Other models as low as ± 10 mV or up to ± 1000 Vdc, down to ± 10 mA or up to ± 10 Adc.

Model MV105J price $1,195.00; Galvanometer option $310.00.

For complete information contact Bob Ross.

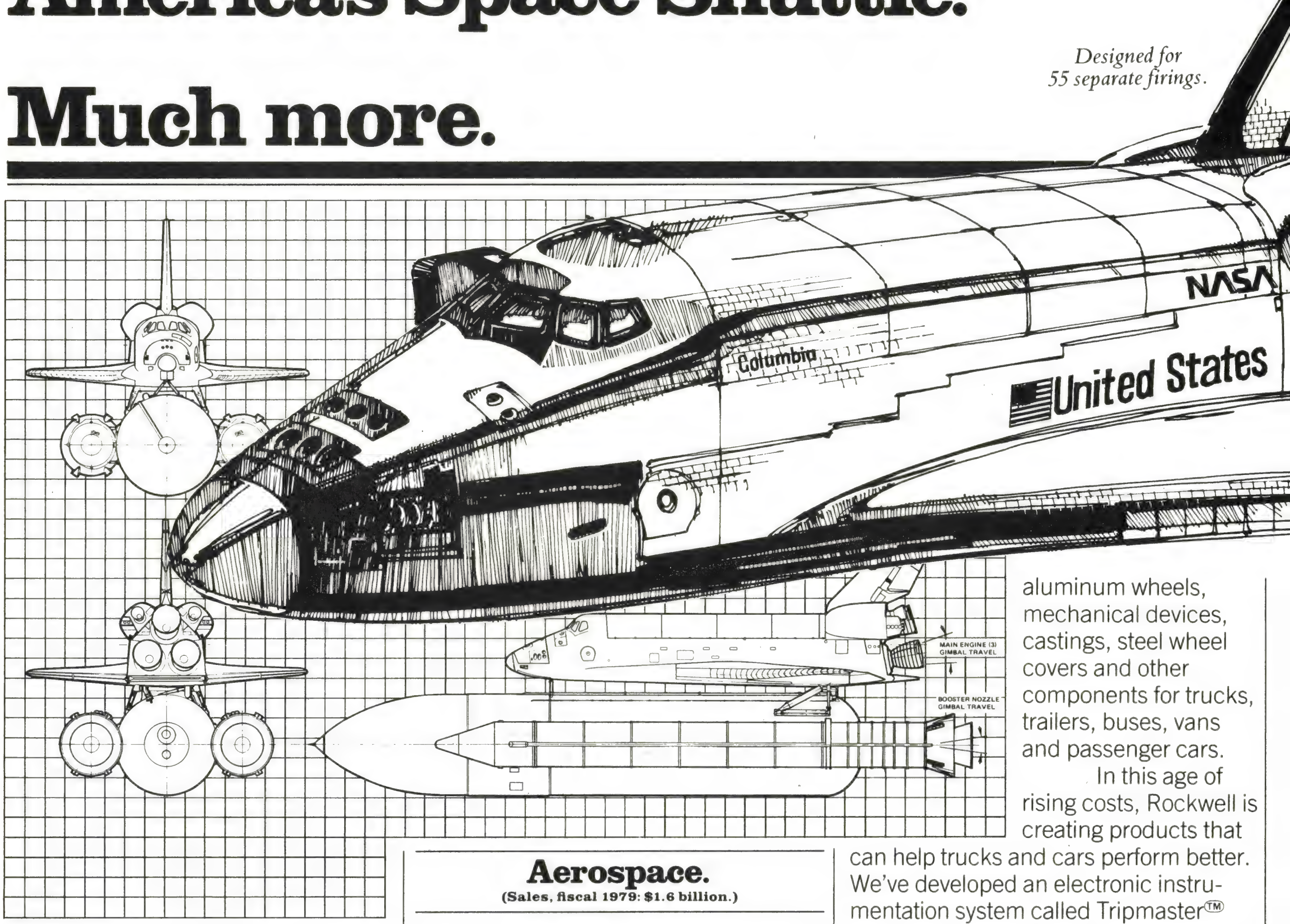
ELECTRONIC
DEVELOPMENT
CORPORATION

11 Hamlin St., Boston, MA 02127, Tel: (617) 268-9696
TLX: 955329 • TWX 710 350-7544

CIRCLE NUMBER 49

Rockwell International is more than a builder of America's Space Shuttle.

Much more.


Designed for 55 separate firings.

If you think of Rockwell International as a company that makes spaceships, you have good reason. We are prime contractor to NASA for Space Shuttle orbiters and their main engines, and for integration of the entire Shuttle system and selected payloads. The Rockwell-built orbiter is the world's first reusable spaceship, capable of at least one hundred missions into space and back. It will launch like a rocket, haul like a truck, work like a space station, then return to Earth and land like a glider. But aerospace is only part of the Rockwell story.

Rockwell International is a major multi-industry company, applying advanced technology to a wide range of products — in automotive, aerospace, electronics and general industries. Following are some examples of our balanced diversification.

Aerospace.

(Sales, fiscal 1979: $1.6 billion.)

Rockwell aerospace involvement extends well beyond the Space Shuttle. Our rocket engines have been used to launch over two-thirds of all U.S.-manned space flights and satellites, and we're building the Navstar satellites that are bringing totally new standards of accuracy to world navigation.

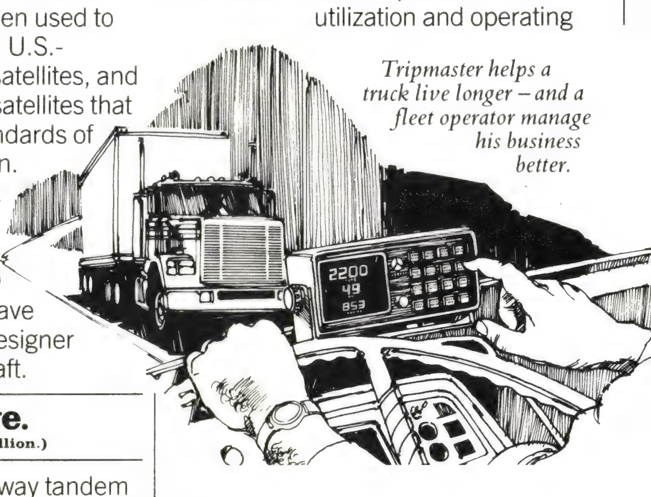
For general aviation, we build Sabreliner® business jets and Jetprop Commander® 840 and 980 business aircraft. And we have a long, proud history as a designer and builder of military aircraft.

Automotive.

(Sales, fiscal 1979: $1.8 billion.)

One-half of the highway tandem tractors in North America are equipped with Rockwell axles — and more than half of the heavy-duty trucks stop with Rockwell brakes. We're also a major supplier of drivelines, steel and styled aluminum wheels, mechanical devices, castings, steel wheel covers and other components for trucks, trailers, buses, vans and passenger cars.

In this age of rising costs, Rockwell is creating products that can help trucks and cars perform better. We've developed an electronic instrumentation system called Tripmaster™ which can provide truck fleet operators with data that can improve vehicle utilization and operating efficiency. Some of our components that can help cut a trucker's fuel consumption and increase payloads include a new aluminum front axle beam, Taper-Leaf® springs and Stopmaster® brakes.


Tripmaster helps a truck live longer – and a fleet operator manage his business better.

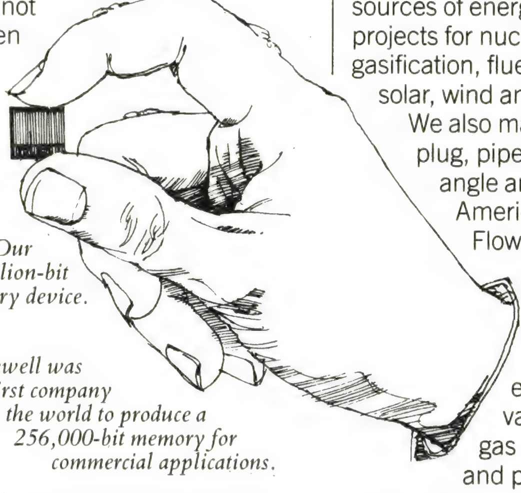
Rocket engine power equivalent to the output of 23 Hoover Dams.

Electronics.

(Sales, fiscal 1979: $1.5 billion.)

We're one of the world's leading suppliers of avionics — communications, navigation and flight control equipment — for air transport, general aviation and government aircraft. We also make microelectronic systems and devices and missile guidance and control systems. And we manufacture and install telecommunications systems for businesses and governments worldwide.

One of Rockwell's latest electronic achievements is the production of bubble domain memories. We developed and market a device measuring about two-fifths of an inch square that can store up to 256,000 bits of information. It has no moving parts and its memory is not erased when power is turned off.



Our quarter-million-bit bubble memory device.

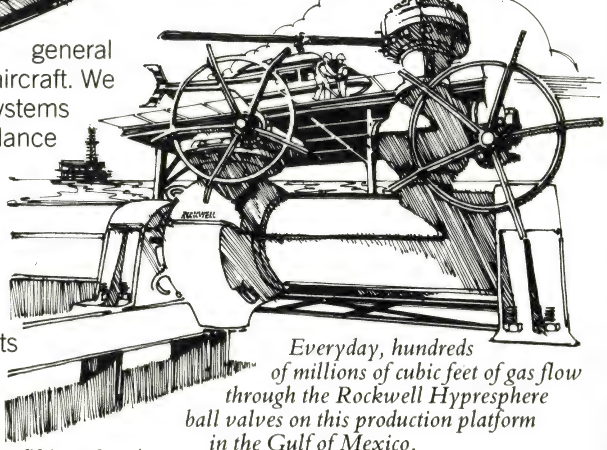
Rockwell was the first company in the world to produce a 256,000-bit memory for commercial applications.

Mechanical mass storage computer memories can now be replaced by smaller, faster, more reliable, more energy-efficient systems.

General Industries.

(Sales, fiscal 1979: $1.2 billion.)

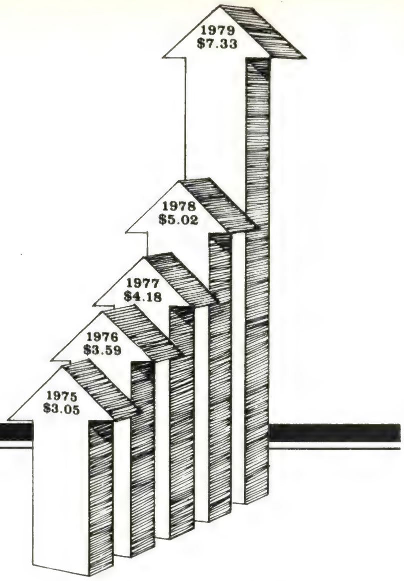
Most of America's major daily newspapers are printed on our Goss presses. We also make textile equipment, industrial sewing machines, power tools, water and gas meters and other products for utilities.



Everyday, hundreds of millions of cubic feet of gas flow through the Rockwell Hypresphere ball valves on this production platform in the Gulf of Mexico.

In addition, our extensive technology is being applied to the world's growing need for alternate sources of energy. We're involved in projects for nuclear energy, coal gasification, flue gas desulfurization, and solar, wind and geothermal power.

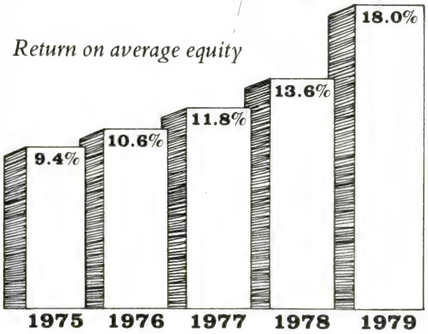
We also manufacture valves — plug, pipeline ball, gate, globe, angle and check valves for America's power needs. Our Flow Control Division is one of the world's leading suppliers of high-technology valving for U.S. and international energy markets. Rockwell valves are used in oil and gas production, transmission and processing; natural gas distribution pipelines; synthetic fuel processing plants; electric power plants; shipboard power plants; and in many other energy-related markets.



Earnings per share

Earnings up in '79 4th consecutive year.

Rockwell International's total sales for fiscal 1979 were $6.2 billion, up 16 percent over $5.3 billion in the prior year. Net income totaled $261.1 million, or $7.33 per share, an increase of 48 percent over 1978 net income of $176.6 million, or $5.02 per share. Return on average equity has increased to 18 percent, which places the company among the top one-third in the *Fortune 100* listing of U.S. industrial corporations. This is a substantial improvement over the previous year and nearly twice that of 1975.



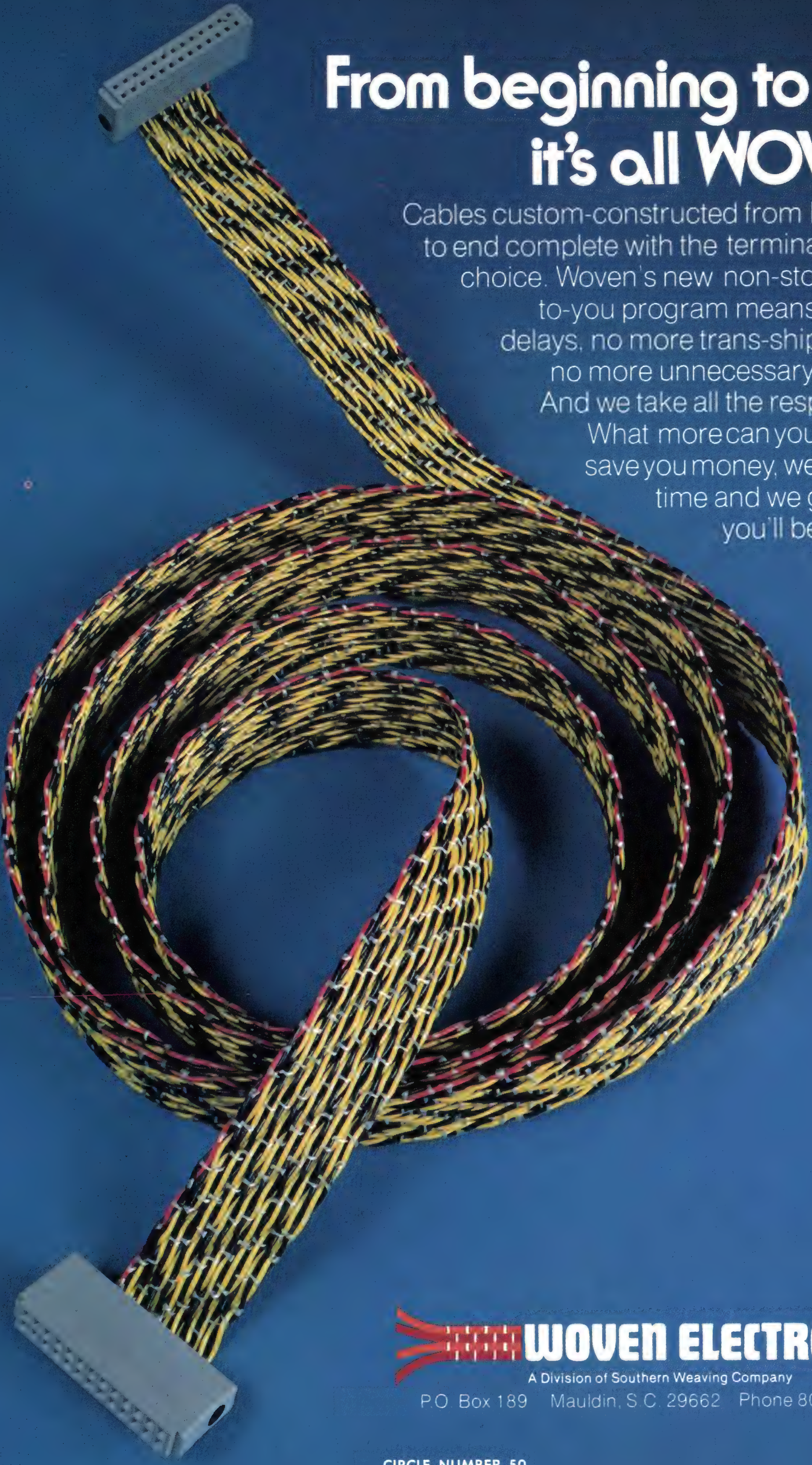
For more of the Rockwell story, or if you're interested in an Engineering career with us, please write: Rockwell International, Dept. 815ED-23, 600 Grant Street Pittsburgh, PA 15219.

Rockwell International

...where science gets down to business

Automotive/Aerospace
Electronics/General Industries

CIRCLE NUMBER 48



From beginning to end it's all WOVEN!

Cables custom-constructed from beginning to end complete with the terminals of your choice. Woven's new non-stop factory-to-you program means no more delays, no more trans-shipping and no more unnecessary expense. And we take all the responsibility. What more can you ask — we save you money, we save you time and we guarantee you'll be satisfied.

WOVEN ELECTRONICS®

A Division of Southern Weaving Company

P.O. Box 189 Mauldin, S.C. 29662 Phone 803/963-5131

CIRCLE NUMBER 50

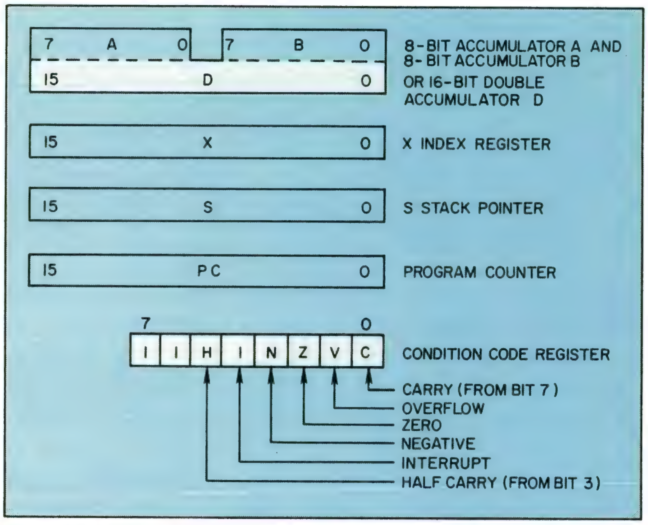
Machine codes create compact instructions that will optimize the powers of MC6801 μC

This article examines the way the MC6801 instruction set optimizes programming. The first article (ELECTRONIC DESIGN, Aug. 2, 1979, p. 76) discussed basics of the single-chip microcomputer and the second discusses the eight operating modes of the processor (see this issue, p. 118).

A well-balanced instruction set can overcome the restrictions upon single-chip microcomputers, in which I/O, ROM and RAM are all limited.

Starting from a base of instructions common to the MC6800 family, the MC6801 one-chip microcomputer gives the programmer 23 additional and significantly more powerful machine codes that foster very compact programs. Moreover, a new dual-bus architecture inside the MC6801 reduces the cycle count of most MC6800-based instructions.

On the MC6801 chip are a CPU, ROM and RAM, parallel I/O ports, a serial I/O port and a programmable counter/timer. The improved CPU architecture supports 16-bit data manipulation within the basically 8-bit CPU.



1. The 16-bit D accumulator combines the A and B accumulators; thus, the MC6801 can perform many 16-bit operations, including an 8 × 8-bit multiply.

New instructions use new accumulator

Although the 6801 has 23 new operation codes, it has only 11 new instructions. These instructions control double-precision data manipulation, increased index-register usage and multiply operations. Seven instructions take advantage of the new double (or D) accumulator highlighted in Fig. 1.

- The Load Double Accumulator (LDD) and Store Double Accumulator (STD) instructions move 16-bit data to and from accumulator D.
- The Add to Double Accumulator (ADDD) and Subtract from Double Accumulator (SUBD) instructions perform 16-bit arithmetic.
- The Shift Left Double Accumulator (ASLD) and Shift Right Double Accumulator (LSRD) instructions each use one less program byte and one less execution cycle than the equivalent operation that shifts 16-bit data in the MC6800.
- A single-byte Multiply instruction (MUL) performs an 8-bit × 8-bit unsigned multiplication in ten cycles.

The LDD and STD instructions can be used in place of MC6800 instructions LDAA, LDAB, and STAA, STAB, which handle the data stored in accumulators A and B. More than 100 other MC6800 instructions for accumulators A and B still influence accumulator D. The most efficient of all the MC6801 machine codes, these accumulator operations are usually completed in just two cycles. The efficiency of the combined A, B and D instruction sequence can be aptly demonstrated, as shown in Fig. 2a.

The ADDD and SUBD instructions use 50% fewer bytes and are 25% faster in execution than earlier instructions. With the older instruction set, 16-bit comparisons require the use of the Compare-X (CPX), Dual Compare-Accumulator (CMP) or Dual Subtract-Accumulator (SUB) instructions. In the 6801 microcomputer, the SUBD eliminates these processing steps, as shown in Fig. 2b.

Interrupt error-protection is also built into the double accumulator instruction. For example, during execution of line "INTBAD" of program "OLDWAY" in Fig. 2b, an interrupt that modifies 16-bit VALUE1 or

Clint Bauer, Automotive Systems Engineer, Motorola Semiconductor Group, 2200 W. Broadway Rd., Mesa, AZ 85202.

Task: Set bit 1 of RAM location $81. Increment location $80 if bit 7 of $81 is set.

"D" instructions not used

```
3000                        ORG     $3000     Comments/# of cycles
3000  D6  81      A         LDAB    $81       Fill B from RAM.       /3
3002  CA  02      A         ORAB    #$02      Set B1 of B.           /2
3004  2A  03   3009         BPL     NOTSET    Branch on B7 CLR.      /3
                  *Bit 7 of B is set: increment $80.
3006  7C  0080    A         INC     $80       Increment $80.         /6
3009  D7  81      A NOTSET  STAB    $81       Store result.          /3
Recap: 11 bytes. 11/17 cycles.
B holds modified $81; A holds original data.
```

"D" instructions used

```
3000                        ORG     $3000     Comments/# of cycles
3000  DC  80      A         LDD     $80       Fill D from RAM.       /4
3002  CA  02      A         ORAB    #$02      Set B1 of D.           /2
3004  2A  01   3007         BPL     NOTSET    Branch on B7 CLR.      /3
                  *Bit 7 of D is set: increment $80
3006  4C                    INCA              Increment A.           /2
3007  DD  80      A NOTSET  STD     $80       Store results.         /4
Recap: 9 bytes. 13/15 cycles.
D holds modified $80, $81.
```

ⓐ

Task: Clear VALUE1's MS bit; then compare with 16-bit VALUE2.

```
                  *"OLDWAY"
0080                        ORG     $80
0080      0002    A VALUE1  RMB     2
0082      0002    A VALUE2  RMB     2
3000                        ORG     $3000     Comments/# of cycles
3000  96  80      A INTBAD  LDAA    VALUE1    Fill A from RAM.       /3
3002  84  7F      A         ANDA    #$7F      CLR B7 of A.           /2
3004  91  82      A         CMPA    VALUE2    Compare MS byte.       /3
3006  26  04   300C         BNE     NOTSAM    Not same: branch.      /3
                  *MSB was same (except B7). CHK LSB.
3008  D6  81      A         LDAB    VALUE1+1  Fill B from RAM.       /3
300A  D1  83      A         CMPB    VALUE2+1  Compare LS byte.       /3
                  *Z bit set for 16 bit equality.
300C  01            NOTSAM  NOP               Process results

                  Recap: 12 bytes. 11/17 cycles.
                  Modified VALUE1 is in D.
```

```
                  *"NEWWAY"
0080                        ORG     $80
0080      0002    A VALUE1  RMB     2
0082      0002    A VALUE2  RMB     2
3000                        ORG     $3000     Comments/# of cycles
3000  DC  80      A INTOK1  LDD     VALUE1    Fill D from RAM.       /4
3002  84  7F      A         ANDA    #$7F      CLR B7 of A.           /2
3004  93  82      A INTOK2  SUBD    VALUE2    Compare 16 bits.       /5
                  *Z bit set for 16 bit equality
                  *C bit indicates VALUE2>VALUE1
                  *D holds 2's complement difference of value
3006  01                    NOP               Process results

                  Recap: 6 bytes. 11 cycles.
                  VALUE1-VALUE2 is in D.
```

ⓑ

```
                  *Multiply subroutines
                  *MULT16: D * MULCND
                  *MUL16X: D * X
                  *Result: D, anwser+2, answer+3
                  *Original D lost, MULCND preserved.
                  *Not re-entrant, MULT16 does not use X.
----------------------------------------------------------------
0080                        ORG     $80
                  *MULCND must exactly precede answer
0080      0002    A MULCND  RMB     2
0082      0004    A ANSWER  RMB     4
3000                        ORG     $3000
3000  DF  80      A MUL16X  STX     MULCND    Optional entry point
3002  DD  82      A MULT16  STD     ANSWER    Stash multiplier
3004  96  81      A         LDAA    MULCND+1  MULCND LSB
3006  3D                    MUL               LSB * LSB
3007  DD  84      A         STD     ANSWER+2  Store partial answer
                  *Get 2nd partial product.
3009  D6  83      A         LDAB    ANSWER+1  D's LSB
300B  4F                    CLRA
300C  97  83      A         STAA    ANSWER+1  Stored LSB unneeded.
300E  96  80      A         LDAA    MULCND    MULCND MSB
3010  3D                    MUL               MSB * LSB
3011  D3  83      A         ADDD    ANSWER+1  Carry out: no chance
                  *MULT8 enters here
3013  DD  83      A MUL8    STD     ANSWER+1  2nd product done.
                  *Get 3rd partial product
3015  DC  81      A         LDD     MULCND+1  MULCND LSB, D's MSB.
3017  3D                    MUL               LSB * MSB
3018  D3  83      A         ADDD    ANSWER+1  Carry out possible
301A  DD  83      A         STD     ANSWER+1  Store 3rd product
                  *Account for carry out
301C  D6  82      A         LDAB    ANSWER    Get D's MSB
301E  49                    ROLA              Carry into A's LSB
301F  84  01      A         ANDA    #$01      A=1 if carry, else 0
3021  97  82      A         STAA    ANSWER    3rd product done.
                  *Get 4th product. D's MSB is in B.
3023  96  80      A         LDAA    MULCND    MULCND MSB.
3025  3D                    MUL               MSB * MSB
3026  D3  82      A         ADDD    ANSWER    Carry out impossible
3028  39                    RTS               Answer in D, answer+2
----------------------------------------------------------------
                  *MULT8: A * MULCND
                  *Result: D, answer+2
3029  97  82      A MULT8   STAA    ANSWER
302B  4F                    CLRA
302C  5F                    CLRB
302D  20  E4   3013         BRA     MUL8      Enter MULT16!
----------------------------------------------------------------
                  *MULT16,MUL16X,MULT8: 47 bytes
                  *MULT8 : 70 cycle subroutine
                  *MULT16:107 cycle subroutine
                  *MUL16X:111 cycle subroutine
```

ⓒ

2. Accumulator operations in the MC6801 can use the 16-bit D accumulator along with the 8-bit A and B accumulators. The programs in (a) show how the D register works with accumulator-addressed operations; the program in (b) the ADDD and SUBD instructions. In (c), the MC6801 is programmed to perform two variations of a 16 × 16 multiplication and one version of an 8 × 16 multiplication—all of which are performed about three times faster than shift-and-add multiplications.

VALUE2 causes the 16-bit comparison to become invalid. On the other hand, instructions LDD and SUBD of program "NEWWAY" perform two 8-bit memory accesses without interruption, making this double-accumulator comparison more reliable.

The MUL instruction also makes effective use of registers A, B and D, first multiplying data A with data B and then storing the result in register D. This efficient multiplication operation can handle higher-order multiplication, as shown in Fig. 2c.

Index registers gain power, too

Three additional instructions that work with the index register have also dramatically improved the CPU's performance. The instructions are Push Index Register (PSHX), Pull Index Register (PULX) and Add B to X (ABX). The PSHX and PULX instructions give the index register direct access to the MC6801's stack register, and increase the efficiency of temporary storage, data transfer and re-entrant programming (Fig. 3a). The ABX command expands the capabilities of the index register by permitting the direct addition of 8-bit data to the 16-bit pointer.

In Fig. 3a, the ABX instruction is used as a new channel for computation. Linear functions are quickly solved using ABX in a table-lookup routine like that in Fig. 3b. Also, ABX represents another option for controlling program flow.

A new operation code for an existing instruction, JSR "DIRECT" provides a direct-addressing mode version of the Jump-to-Subroutine (JSR) instructions. With JSR "DIRECT", just 2 bytes of program are needed to call subroutines that start in the first 256 locations of the MC6801 memory map. This lowest addressing range offers external address space in the expanded modes of the MC6801, as well as the internal registers

Feeling the heat?

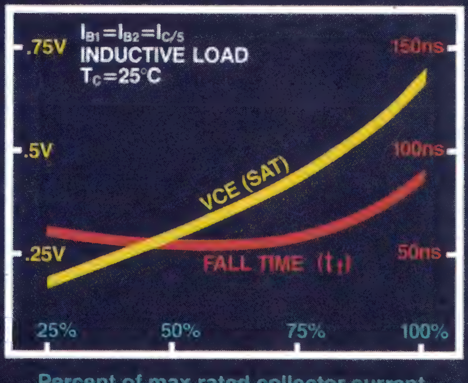
Cool it with new Switchpower™ transistors from General Electric

If you're "feeling the heat" from competition and tight design goals, you need the "Cool Performers," General Electric *Switchpower* transistors.

Switching speed, efficiency and secondary breakdown are the prime factors you must consider when selecting transistors for improved performance in high-frequency, off-line, switching power supplies. New Switchpower transistors are optimized to provide you with the best combination of high voltage, ultra low switching losses and wide safe operating area (SOA). The result is a cooler operating device with improved reliability and greater circuit efficiency.

Switchpower transistors incorporate an innovative emitter design which significantly reduces inductive crossover time (t_c) and fall time (t_f) while maintaining high gain and low V_{CE} (SAT).

They have excellent high current characteristics without excessive base drive and inductive turn-off SOA extending to maximum rated voltage and current. Best of all, these features are fully characterized at 25°C and 100°C to give you good predictability under "Worst Case" conditions.



Percent of max rated collector current

Switchpower transistors are available in five current ranges with V_{CEV} ratings of 400 to 650 volts. In TO-3 are Ic(cont) 15 Amps D64VS3-5 and 2N6676-8, 7.5 Amps D64VP3-5, and 5 Amps D64VE3-5. Also available in plastic TO-220AB are Ic(cont) 4 Amps D44TE3-5 and 2 Amps D44TD3-5.

For more information, contact your nearest GE Sales Office, authorized GE Distributor, or write: General Electric Company, Box 44D, West Genesee Street, Auburn, NY 13021. 222-17

GE SWITCHPOWER TRANSISTORS

The Cool Performers for hot new ideas in switching.

GENERAL ELECTRIC

Storage Scopes.

Choose the one to match the job.

The industry's widest selection. You'll find them throughout the world, in research and development labs, in service centers, and in the field. Each oscilloscope offers a unique combination of features ideally suited for a particular application. Choosing from the widest selection of storage speeds and modes to match the job is easy with the Tektronix Storage Scope Selection Guide.

Performance. The 7000 Series finds wide use in laser fusion labs in single shot analysis, glitch detection, and ECL logic design by offering the fastest storage available. Writing rates up to 2500 cm/μs, allow signals to be stored to speeds in excess of 250 MHz and with real-time bandwidths to 400 MHz.

Flexibility. Tektronix realizes that tools must be flexible. That's why both the 7000 and 5000 Series offer you a wide selection of storage mainframes… some that offer three different storage modes …and a broad selection of plug-ins that lets you custom tailor a package to meet your specific measurement need.

Mobility. If you need to perform tests in several locations with a scope that can capture and store slow, randomly timed events or very fast signals, our 400 Series meets the challenge.

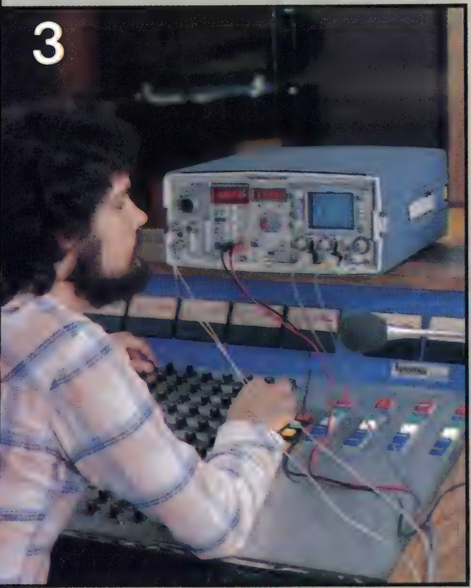
Portability. For climbing ladders or traveling to remote locations where power is not available, we offer storage portables weighing from 1.6 kg (3.5 lbs), with a wide range of bandwidths and writing speeds.

Configurability. Our TM 500 Series offers a storage plug-in scope that you can combine with generators, multimeters, counters, or other plug-ins to create a cost-effective, multitest capability in one package.

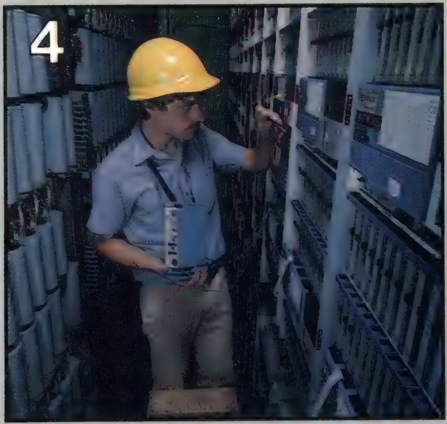
Service and Support. There are hundreds of Tektronix Service Engineers located throughout the world to calibrate and maintain your Tektronix Scope.

Send for your FREE Selection Guide. Whatever your storage application, we've got the scope to match the job. So send for your free Selection Guide today. Descriptions of each storage mode and technical data on every model will help you select the one that's right for your application.

3



4



Tektronix®
COMMITTED TO EXCELLENCE

5

Send me the Tektronix Storage Scopes Selection Guide.

Name

Company

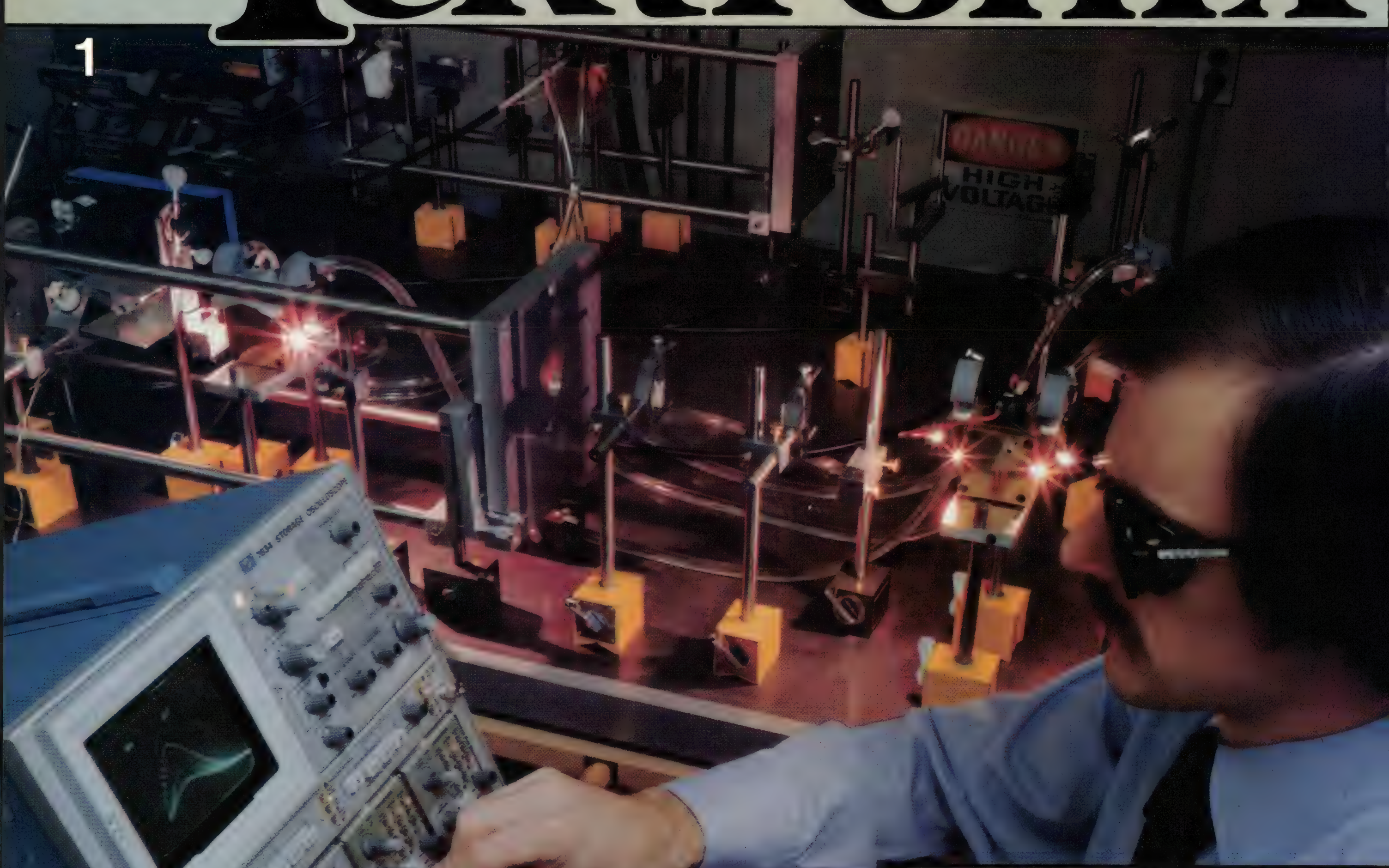
Address

City State Zip

Mail to: Tektronix Storage Scopes
Tektronix, Inc.
P.O. Box 1700

Tektronix

1



2

Tektronix offers 15 storage scopes and the widest selection of storage modes. Here is how just a few of those scopes are being used today.

1 The FAST storage mode of the 7834 being used to capture high speed laser pulses.

2 The extremely bright display provided by the 466 in variable persistence mode makes it easy to view low rep rate switching performance.

3 The TM 500 with an SC 503 bistable storage plug-in being used for audio maintenance.

4 The highly portable 214 at work in system troubleshooting.

5 The long view time provided by bistable storage in the 5111 is useful for the study of pain threshold data.

Picture a line of low-cost fully-enclosed carbon-film trimmers...

And Its Circle of "Special" Friends.

Spectrol now offers a low-cost line of carbon-film trimmers that are fully-enclosed and available in two sizes–the 5/8-inch Model 77 and the 3/8-inch Model 76. They come in nine standard configurations, as shown in the photo, and they are also available in a great variety of special configurations with various spindles, panel mounts, and other optional features. Resistance range is from 100 ohms to 10 megohms. Send for a data sheet. Call for a quote or a free sample.

Spectrol

SPECTROL ELECTRONICS GROUP

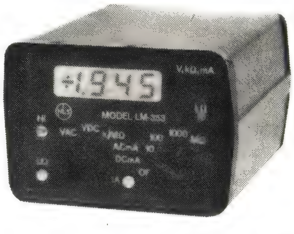
UNITED STATES **Spectrol Electronics Corporation** P.O. Box 1220, City of Industry, Calif. 91745, U.S.A. • (213) 964-6565 • TWX (910) 584-1314
UNITED KINGDOM **Spectrol Reliance Ltd.** Drakes Way, Swindon, Wiltshire, England • Swindon 21351 • TELEX: 44692
ITALY **SP Elettronica SpA** Via Carlo Piscane 7, 20016 Pero (Milan) Italy • 35 30 241 • TELEX: 36091
GERMANY **Spectrol Electronics GmbH** Oberauerstrasse 15, 8000 Munich 70 West Germany • (089) 7145096 • TELEX: 05-213014

CIRCLE NUMBER 52

You are Invited!!!

to Examine the Prestigious, Portable Volksmeter Collection.

● Greatest selection. ● Smallest size. ● Low prices. ● Greatest portability. ● Excellent performance. ● Dependability. ● Reliable.



- VDC, VAC, Ohms, Low Ohms, DCmA & ACmA.
- Three & one-half digits.
- Automatic zero.
- Automatic polarity.
- Battery operation.*

LM-353
With LCD Readout
& 100 Hr. Battery Life

- Measures VDC, VAC, Ohms, DCmA & ACmA.
- Full four digits.
- Automatic zero.
- Automatic polarity.
- Battery powered with charger unit included.

LM-4A
With LED Readout

- VDC, DCmA, Ohms and RMS VAC & ACmA.
- Three & one-half digits.
- Automatic zero.
- Automatic polarity.
- Battery or AC line operation.*

RMS-350
With LCD Readout

Size: 1.9"H x 2.7"W x 4.0"D/Weight: 9.2 oz

SPECIFICATIONS

MODEL	RANGES	DC ACCURACY	RESOLUTION	DIGITS	PRICES
LM-3A	VDC, VAC, DCmA & ACmA 1, 10, 100 & 1000. *100% over-range - 1000 VDC or peak AC & 1A maximum. RMS-350 displays true RMS in VAC and ACmA modes. OHMS 1 kΩ, 10 kΩ, 100 kΩ, 1 MΩ & 10 MΩ LM-353 also has 0.1 kΩ range.	±1% Rdg	1 mV	3	$134.00
LM-300		±1% Rdg	1 mV	3	$125.40
LM-3.5A*		±0.5% Rdg	1 mV	3-1/2	$165.85
LM-350*		±0.5% Rdg	1 mV	3-1/2	$154.10
LM-353*		±0.5% Rdg	1 mV	3-1/2	$155.05
RMS-350*		±0.5% Rdg	1 mV	3-1/2	$228.80
LM-40A		±0.1% Rdg	100 µV	4	$209.00
LM-4A		±0.03% Rdg	100 µV	4	$250.00

LM "A" Series display - LED's; LM-300, LM-350, LM-353 & RMS-350 - LCD's.

*LED-display models—NiCad batteries and charger unit included.
LCD-display models—batteries and charger unit *not* included.

NLS products are available from Nationwide Electronic Distributors. Send for our brochure today!

NLS
Non-Linear Systems, Inc.
Originator of the digital voltmeter.
Box N, Del Mar, California 92014 Telephone (714) 755-1134

CIRCLE NUMBER 51

In many cases, the direct-addressing mode saves time and bytes with every accumulator/memory transfer. As an alternative, though, "memory change" instructions (such as CLR and INC) can also alter memory, but do not require the use of either accumulator. Whereas the balance between these approaches was previously about equal, the improved Store Accumulator instructions now make the first method more efficient.

The improvement in "memory-store" execution can indirectly reduce the byte count in certain programs. In Fig. 2a, 2 bytes are saved (at no loss in speed) when accumulator-type programming is used. Without the improvement in cycle timing, the INC $80 instruction would have been faster, and perhaps preferable.

Hardware tweaks ease programming

Even the hardware design of the MC6801 helps to optimize programs. All processor registers are freed during interrupt service, since their contents are automatically stored under hardware control. Interrupt service routines are efficient, requiring no software overhead to perform the job. Also, the processor's internal RAM and registers are purposely placed in the direct addressing range of the CPU. Direct-mode instructions access a single-byte operand to specify the data address, thus saving program bytes and execution cycles.

The system program in Fig. 5 includes initialization software that loads the stack pointer and initializes various registers. The program places the stack at the top of the RAM ($00FF), then clears all 128 internal RAM words. Two hardware features save 3 program bytes in this application: $00FF is available from internal registers after the processor is reset; and RAM words to be cleared are located near the stack.

Another hardware feature brings 16-bit data $FFFF to accumulator D by using the 2-byte direct-addressing mode, rather than the 3-byte immediate-addressing mode. Data direction registers DDR1 and DDR2 control the operation of ports 1 and 2 of the processor yet are not readable by the CPU. Instead, when the address locations of these registers ($0000 and $0001) are read, $FF returns so that the following near-equivalent operations are possible in the 6801:

```
        LDD    #$FFFF    = LDD  DDR1
        SUBD   #$0001    = ADDD DDR1
        ADDD   #$0001    = SUBD DDR1
   (three program bytes)  (two program bytes)
```

The latter two of these instructions simulate DEC D and INC D, which are not otherwise available as single instructions in the MC6801.■■

For a free pocket programmer's guide, Circle No. 319

How useful?	**Circle No.**
Immediate design application	**556**
Within the next year	**557**
Not applicable	**558**

flag of MUL. Mixing status flags like this can boost efficiency, and provide very compact code.

For faster execution of 61 of the 198 MC6800 machine codes, the MC6801 processor has an enhanced internal architecture that splits the data bus into two. The improvement for some codes is shown in the table. The average improvement is a 25% decrease in cycle count for the instructions involved.

The dual internal data bus saves execution cycles by providing alternate transfer paths within the processor. For example, direct-addressing-mode instructions use their first two cycles to fetch the op code and operand. In the MC6800, two additional cycles are required to write the accumulator contents to memory. In the MC6801, only one cycle is needed, since the dual bus permits address and data to be routed simultaneously.

Thus, the improved cycle times speed up system throughput 10 to 15%. Beyond this, programmers concerned with efficiency can improve program speed with the new instructions and the shifted tradeoff in time-vs-byte-count associated with several software techniques.

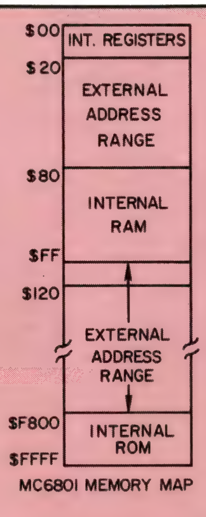
Programming technique determines efficiency

When programs are being written, the use of stack and index operations will usually save program bytes at the expense of execution speed. However, many system tasks are tied to a strict time budget, which may present this type of programming. When a time penalty can be tolerated, the re-entrant capability demonstrated in Fig. 3a will save 30 or more bytes of program otherwise needed to provide duplicate subroutines. Index and stack operations were sometimes ruled out before because of speed; but the improved cycle speed of the MC6801 will often favor these operations, which save program space.

```
                                 *Output pulse calculation routine
              0002           A   PORT1    EQU    2         6801 PORT1 at $0002
0080                                      ORG    $80       RAM at $0080
0080          0001           A   VAL1     RMB    1
0081          0001           A   VAL2     RMB    1
0082          0001           A   VAL3     RMB    1
0083          0002           A   OUTCNT   RMB    2         Output pulse width
3000                                      ORG    $3000
                                 *Place multipliers in A & B, then multiply
3000    DC    80             A            LDD    VAL1      VAL1,VAL2, put in A,B
3002    3D                                MUL              C flag follows bit 7
                                 *Check whether VAL3 needs to be involved
                                 *PORT1 MSB set: no VAL3. MSB clear: use VAL3.
3003    DE    02             A            LDX    PORT1     N-flag: PORT1's MSB
3005    2B    05      300C                BMI    STOWIT    Input pin says no
                                 *VAL3 needs to modify calculated pulse.
                                 *First, round off VAL1*VAL2 to 8 bits.
                                 *Note: C bit from MUL above is still valid.
3007    89    00             A            ADCA   #0        A=(A)+(0)+(C-BIT)
                                 *Now multiply rounded value with VAL3
3009    D6    82             A            LDAB   VAL3
300B    3D                                MUL              D=VAL1*VAL2/256*VAL3
                                 *Store calculated output pulse duration
300C    DD    83             A   STOWIT   STD    OUTCNT
```

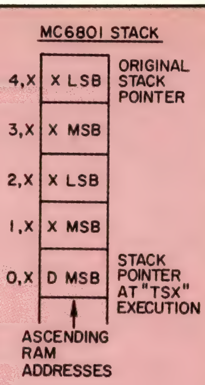
4. By using the ADCA instruction to preserve math accuracy during a truncation of a MUL operation, the program shown performs automatic bit testing. LDX provides automatic program direction even though 15 bits of X are ignored.

```
                   *Program initialization
0009                      ORG $0009        Specify int. regs.
0009      0002   A COUNTR RMB 2            Reset init. to $0000
000B      0002   A CMPREG RMB 2            Reset init. to $FFFF
FFFE                      ORG $FFFE        Reset vector
FFFE      3000   A        FDB RESTRT
3000                      ORG $3000
3000 9E 0A       A RESTRT LDS COUNTR+1     Stack loaded W/$00FF
                   *(LDS #$00FF must be used if this code is
                   *entered by any means except reset.)
3002 30                   TSX              X=SP+1=$0100
                   *TXS replaces "LDX #$XXXX", saving 2 bytes.
                   *Clear internal RAM from $80-$FF
3003 6F 1F       A RAMCLR CLR $1F,X        CLRS $20-$11F
3005 09                   DEX              When X=0, Z bit sets
3006 26 FB 3003           BNE RAMCLR       Loop until $20 CLRD
                   *$0020-$011F now cleared. For most systems,
                   *only internal MC6801 RAM is affected!
                   *At this point, X=$0000,S=$00FF,
                   *while A and B are undefined.
```



5. For a start-up initialization, this program (left) sets up the stack pointer and clears the portion of memory from $20 to $120 (right), to provide the system with a known starting state for all memory.

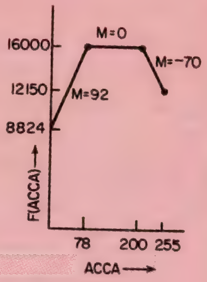
```
                              *M16TRE: D * X W/ Truncated 16 bit answer.
                              *Re-entrant: fore and background may call.
                              *Answer is in X, rounded off. X LSB * D LSB
                              *is ignored—there is a 1 in 4 chance that
                              *the 16 bit answer is 1 count low.
                              *Each call uses 5 stack bytes.
                              ***************************************************
3000                                   ORG   $3000
                              *Temporary storage of data on stack
3000  3C                      M16TRE   PSHX              X LSB, then X MSB
3001  3C                               PSHX              X LSB, then X MSB
3002  36                               PSHA              D MSB
3003  30                               TSX               SP+1 placed in X.
                              *Re-entrancy now satisfied. See RAM chart.
                              *Ready to multiply. D LSB in B.
3004  A6  01          A                LDAA  1,X         X MSB
3006  3D                               MUL               X MSB * D LSB
3007  ED  01          A                STD   1,X         Store partial answer
3009  A6  00          A                LDAA  0,X         D MSB
300B  E6  03          A                LDAB  3,X         X MSB
300D  3D                               MUL               X MSB * D MSB
300E  A7  03          A                STAA  3,X         Store 2nd partial
3010  A6  04          A                LDAA  4,X         X LSB
3012  E7  04          A                STAB  4,X         Store 2nd partial
3014  33                               PULB              Get D MSB
                              *Stack pointer moved, but not index reg.
3015  3D                               MUL               X LSB * D MSB
3016  E3  01          A                ADDD  1,X         XL*DM + XM*DL
                              *Carry out is important—add to 3,X
3018  24  02     301C                  BCC   NOPROB      No carry!
301A  6C  03          A                INC   3,X         Adds 256 to XM*DM
                              *Now fix stack, get XM*DM in X
                              *(PULX eases data transfer)
301C  38                      NOPROB   PULX
301D  38                               PULX              Mission accomplished
                              *To round off, inc. X if B's MS bit set
301E  5D                               TSTB              Examine B's MS bit
301F  2A  01     3022                  BPL   NOTRND      Do not round up
3021  08                               INX               Round up
                              *To truncate, A is added to X.
3022  16                      NOTRND   TAB               Move A to B for ABX
3023  3A                               ABX               Add B to X
3024  39                               RTS               Answer is in X
                              ***************************************************
                              *M16TRE: 37 bytes. 111-120 cycles.
```



ⓐ

```
                              *TWOSLQ: Performs lookup of signed-slope
                              *Data table specified in RAM LOC. "TABPTR".
                              *ACCA is the lookup pointer.
                              *Interpolation gives 16-bit answer in D.
                              *Table organization: Endpoint, slope, offset.
                              ***************************************************
0080                                   ORG   $80         RAM at $0080
                              *TABPTR contents point to 1st byte of table
0080      0002        A       TABPTR   RMB   2
3000                                   ORG   $3000
3000  DE  80          A       TWOSLQ   LDX   TABPTR      Get start of table
3002  C6  04          A       TWOSLR   LDAB  #4          4 bytes per entry
3004  20  01     3007                  BRA   SRCHIN      Skip ABX 1st time
                              *Actual lookup of endpoints:
3006  3A                      SRCH     ABX               Examine next entry
3007  A0  00          A       SRCHIN   SUBA  0,X         Compare input, endpnt
3009  25  FB     3006                  BCS   SRCH        Still not big enough
                              *Endpoint found: A= # CNTS from endpoint
                              *Now interpolate
300B  E6  01          A                LDAB  1,X         Get slope
                              *Pos. or Neg. Slope? Sign bit is LSB of 1,X
300D  54                               LSRB              Adjust multiplier
300E  24  07     3017                  BCC   POSSLP      Positive slope
                              *Negative slope
3010  3D                               MUL
                              *Get 2's complement
3011  43                               COMA
3012  50                               NEGB              B=$00: C-bit clears
                              *The following doesn't change A unless B=$0
3013  82  FF          A                SBCA  #$FF        "INCA" at B=$00
3015  20  01     3018                  BRA   NEGSLP
3017  3D                      POSSLP   MUL
3018  E3  02          A       NEGSLP   ADDD  2,X         Math: Y=MX+B
301A  39                               RTS               Return
                              ***************************************************
                              *TWOSLQ: 27 bytes. 36/45+(10*#SRCHS) cycles
```

ⓑ



```
*F(ACCA) Lookup Table

      ORG  $4000
RIGHT FCB  200,2*70+1
      FDB  16000
FLAT  FCB  134,2*0
      FDB  16000
LEFT  FCB  178,2*92
      FDB  8824
```

3. Additional index register and stack operations create more compact programs and extend the re-entrant capabilities. The programs shown use PSHX and PULX instructions to give X direct-access to the stack (a); and the ABX to facilitate table look-up operations (b).

and RAM.

The MC6801's Branch Never (BRN) instruction brings the total of MC6800-family branch instructions to 16. Like the others, BRN executes by accessing its single operand as the processor prepares to branch, which in this case is never allowed. The BRN operand is unique to the MC6801—its numeric value does not affect program flow.

Do use Branch Never

As a 2-byte, 3-cycle no-operation, this instruction can be used for software time delays. During program debug, any 2-byte instruction (including other branches) can be nullified easily. All that is needed is replacement with BRN.

The BRN operand, which can take on any 8-bit value, can also be used to advantage when program storage bytes are at a premium. For example, a program can conserve bytes by using BRN to "skip" single-byte instructions. Though unorthodox, this procedure can be beneficial in single-chip microcomputer applications, by increasing the over-all utility of the MC6801's internal ROM.

Other instructions from the MC6800 family have been improved to increase their efficiency or the number of operations they perform. One of these, the Compare-X (CPX) controls the status flags C, N, V and Z, to reflect true 16-bit comparison (only bit Z was useful in the MC6800). This additional information magnifies software versatility by indicating signed and unsigned relative magnitude, as well as equivalence. For example, CPX can offer the same 16-bit comparison as programmed "NEWWAY" shown in Fig. 2b, except that bit 15 of VALUE1 can not be cleared and the 2's complement difference is not available. Since these features are usually unnecessary anyway, CPX is often the simplest method for performing 16-bit relative comparisons.

Six new mnemonics add convenience

Along with the 23 new machine codes, the MC6801 instruction set has six other new mnemonics. These mnemonics include a family of logical shift left instructions that supplement the already available arithmetic shift left instructions. The Branch if Carry Clear (BCC) is now known as BHS (Branch if Higher or Same), and Branch if Lower (BLO) is the same as the older Branch if Carry Set (BCS). Both allow a mathematics-based decision to be made conveniently after subtract or compare operations.

The new operations of the MC6801 microcomputer manipulate the processor status flags much as did similar instructions in the older MC6800.

The CPX instruction also alters the status flags when appropriate; and the MUL instruction sets status flag C to the value of accumulator B, bit 7, which is part of the 16-bit multiplied answer placed in A and B. Thus, flag C can directly round-off a result to 8 bits by using the extra instruction ADCA shown in Fig. 4. There is never a real "carry" from instruction MUL, but using flag C for rounding is handy because it influences more instructions than can flags H, N, V or Z.

During computations, the status flags interpret the results of arithmetic operations, permitting both negative and positive numbers (or even BCD) to be processed with the strictly binary ALU in the processor. Bit testing can be done for input/output control; for example, the instructions BIT and AND are interpreted by the CPU flags they control.

Instructions for testing

Other MC6801 instructions are handy for performing tests on bits 0, 6 or 7. For example, both the Shift and Rotate commands influence status flags N and C as they monitor these important end-bits. The most efficient processor test, however, operates on bit 7, and occurs with every Load and Store instruction. LDX, LDD, LDS, LDA, STX, STD, STS and STA automatically deliver the status of the most-significant bit involved (and Z-flag information as well). Since both of the accumulators are in use, the LDX PORT1 instruction provides an efficient test that delivers the desired N-flag in just four cycles, as shown in Fig. 4. Even the TST PORT1 instruction (an alternative that would work under different circumstances) requires two more cycles than LDX PORT1.

Ignoring bits

Also included in the MC6801 are instructions that can adjust particular status bits while ignoring others. For instance, in Fig. 4, a decision is required before using the present C-flag. The TST PORT1 instruction adjusts C, as well as N, Z and V, rendering this instruction unusable. However, the LDX PORT1 instruction delivers N-flag information, upon which the branch decision will be based, while retaining the C-

Comparison of cycle times

Description of instruction	Execution cycles required	
	6800	6801
All "store" operations*	N	N−1
All "indexed" operations*	M	M−1
Push accumulator	4	3
Pull accumulator	5	4
Dec./Inc. X or S	4	3
TXS, TSX	4	3
All branches	4	3
Subroutine branch (BSR)	8	6
Subroutine jump (JSR ext.)	9	6
Subroutine jump (JSR ind.)	8	6

*"Indexed store" operations benefit doubly.

Programmable signal-processor LSI rivals analog-circuit filters

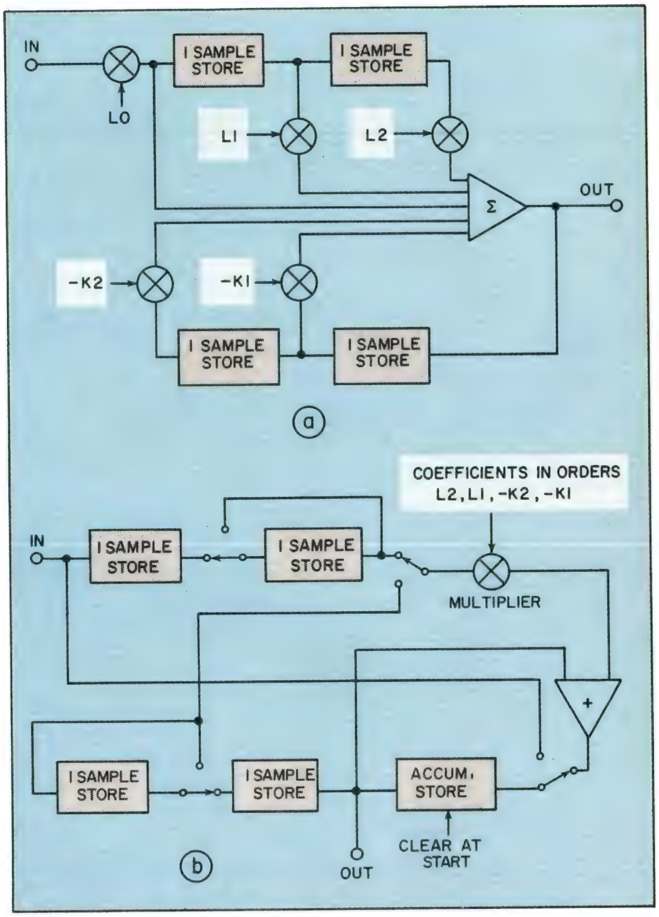
With special-purpose hardware now available, digital filtering can carry out functions previously realizable only by analog techniques. Switching from analog to digital filters reaps several technical advantages, including flexibility—almost any analog-filter characteristic can be programmed—and high stability and reliability at increasingly competitive costs.

Digital filters can be implemented with a general-purpose microprocessor system, with a bit-slice assembly or with a specialized programmable signal-processing LSI chip (such as the AMI S2811; see "Signal-Processor Architecture").

At low speeds—to a few hundred kHz for seismological, medical and biological data—the general-purpose microprocessor can be very effective. Low-order filters, in particular, can be realized quite readily with a single-chip, general-purpose microprocessor, such as AMI's S6801. However, a bank of complex filters would need the more powerful capabilities of a faster 16-bit machine (such as AMI's S9900), together with several associated memory and peripheral-control chips.

At intermediate sampling speeds—to about 100 kHz—the AMI S2811 signal-processing peripheral (SPP) is available for customer programming, and will soon be available preprogrammed for a wide variety of standard filter configurations. Dedicated custom-designed LSIs also are possible, but they are restricted to high-volume production or where high single-unit costs can be tolerated. Several companies (including AMI) offer cell, or universal-logic-array (ULA) type, custom-design facilities for producing such LSIs, as an intermediate stage to a full custom design.

For high sampling frequencies—above about 100 kHz—special-purpose LSI chips, at present, are not fast enough: Systems assembled with fast ICs, MSIs and discrete components become necessary. Before the introduction of the new special-purpose signal-processing chips, like the AMI S2811, this approach was the only way available, even at low speeds. Microprocessor systems made up with n-bit-slice chips are particularly suitable for high-speed processing. They provide a great boost to the capabilities of TTL circuits, while reducing the parts count. The n-bit-slice circuits can be microprogrammed to execute digital-filter algorithms efficiently. However, to achieve the maximum speed capability of the n-bit slice, ECL would be required.



1. Digitally implementing a filter involves multiplying data by constant coefficients (L_0, L_1, L_2, K_1, etc.), storing the data samples and summing the results. All the operations can be done in parallel (a) or, to save hardware, the complex multiplier can be multiplexed (b) and the operation performed serially.

Once the general technology is selected, the configuration of the processor's arithmetic unit is the next item that most affects throughput speed: At high speed, parallel arithmetic becomes almost mandatory; at low speeds serial arithmetic is simpler, and hardware can be saved by multiplexing the processor.

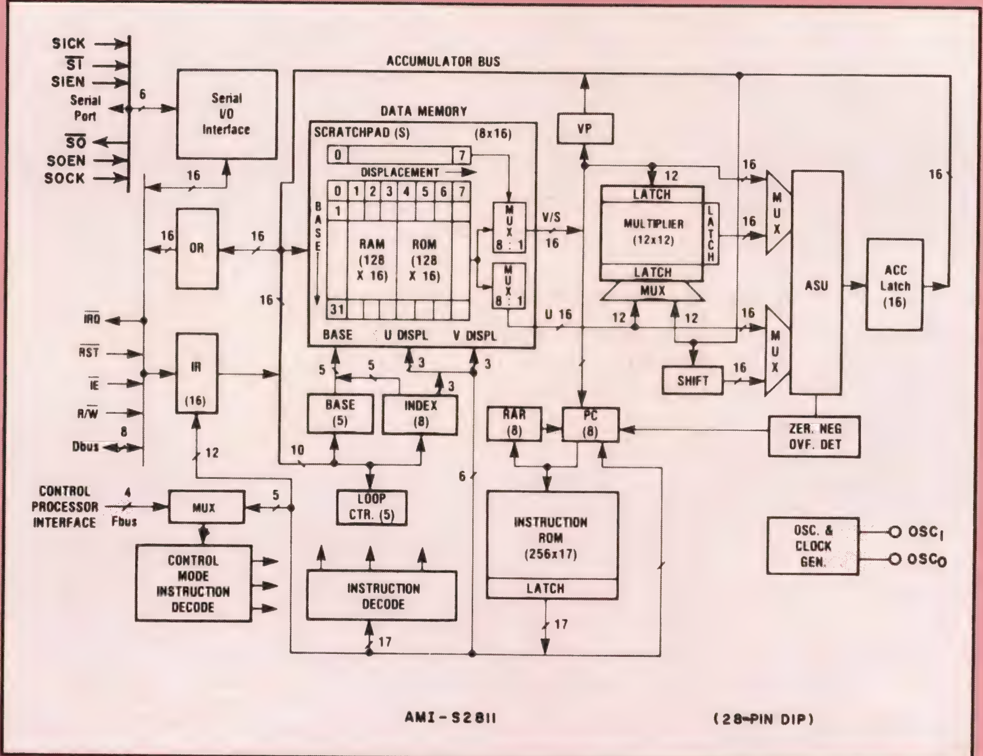
No matter what hardware and architecture are

Dr. Gwyn P. Edwards, Telecommunications Applications Engineer, American Microsystems, Inc., 3800 Homestead Rd., Santa Clara, CA 95051.

employed, multiplication is the most complex function in implementing digital filters. Therefore, multiplexing a single multiplier to perform all multiplications could save substantial hardware.

As Fig. 1a shows, four multiplications are needed to implement a second-order filter section. However, not only can the simplified multiplexing arrangement of Fig. 1b perform all multiplications with one multiplier, but the adder now can be easily implemented in the serial system as a single-input, clearable accumulator, using a two-input adder for addition, storage and feedback. As a result, the whole arithmetic unit—multiplier and accumulator—is multiplexed (Fig. 2), with data and coefficients stored in memories and sequentially supplied in proper order to the unit. Even with such a low level of multiplexing,

Signal-processor architecture



This special-purpose arithmetic processor—with on-chip ROM, RAM, multiplier, adder/subtractor, accumulator and I/O—is organized in a pipeline structure. The multiplier can multiply, add and store two 12-bit numbers in about 300 ns.

Pinout nomenclature

Microprocessor interface (16 pins)

D_O-D_7 — (*Input/Output*) Bidirectional 8-bit data bus.

F_O-F_3 — (*Input*) Control-mode/operation decode.

$\overline{IE}$ — (*Input*) Interface Enable.

R/$\overline{W}$ — (*Input*) Read/Write select. When high, SPP output data are available on the data bus.

$\overline{IRQ}$ — (*Output*) Interrupt Request. An open-drain output that goes low when SPP needs service.

$\overline{RST}$ — (*Input*) Reset. When low, it clears all internal registers, counters and modes, and initiates program execution at location 00.

Serial interface (6 pins)

SICK, SOCK — (*Input*) Serial Clocks. Shifts data into or out of the serial port.

$\overline{SI}$ — (*Input*) Serial Input. Data enter MSB first and are inverted.

SIEN — (*Input*) Serial Input Enable. Length of input word (16 bits maximum) determined by enable width.

SO — (*Output*) Serial Output. Three-state; output MSB first and inverted.

SOEN — (*Input*) Serial Output Enable. Length of output (16 bits maximum) determined by enable width.

Miscellaneous

OSC$_i$, OSC$_0$ — External 20-MHz crystal (with suitable capacitors to ground) across these pins provide the time base. Or, an external clock can be applied to the osc$_i$ input.

V_{CC}, V_{SS} — V_{CC} = +5 V, V_{SS} = 0 V (ground).

flexible, complicated universal filter sections can be readily realized.

Many multiplying techniques are possible, with methods classed as all-parallel, all-serial and serial-parallel.

Serial/binary multiplication is simplest

Serial, binary multiplication requires the least amount of hardware (Fig. 3a). But it is also the slowest way to go, and generally cannot be used for digital-filter implementation, especially in high-speed, real-time applications. A complete operation takes M(M+N+1) clock cycles, where M and N are the number of bits in the multiplied numbers.

Parallel-serial techniques (Fig. 3b), often called "pipelining," are substantially faster, since they require just (M+N) clock cycles—far fewer than the all-serial method. But more hardware is needed.

The fastest method is parallel addressing a look-up table. All 2^{M+N} possible products of an M × N-bit multiplication are stored in a fast ROM. Addressing the memory with the M and N bits in parallel gives the product in one quick step. But a 16 × 16-bit multiplication would require a huge memory capacity of over 4-billion 32-bit words.

The solution? Break each word into four 4-bit nibbles, and a more reasonably sized 4 × 4 ROM with 256 address locations can be used sequentially. The partial products, after being properly shifted to preserve significance, can be summed to get the final product. Although this multiplexing saves hardware, speed is sacrificed. Four-separate look-up tables operating in parallel with the partial products summed simultaneously, of course, would produce a quicker result.

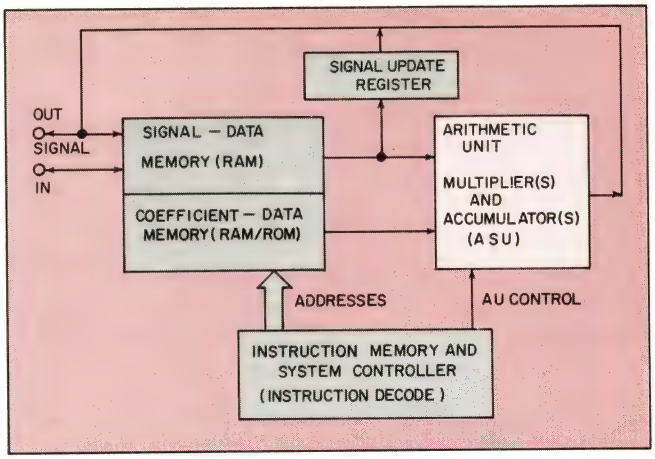
On the other hand, a direct shift-and-add process such as Booth's algorithm can do the multiplication. Like the look-up-table system, a Booth's-algorithm multiplier can be simplified by splitting the input data into nibbles and then summing the partial products. The AMI S2811 employs Booth's technique by working with three bits at a time (Fig. 4).

The algorithm operates on binary numbers in the two's-complement fractional form, where the most-significant bit in front of the decimal represents the sign of the number (see "Booth's Multiplication"). In the algorithm, a number, Y, with m+1 bits can be represented as the sum of two (or more) adjacent bits at a time:

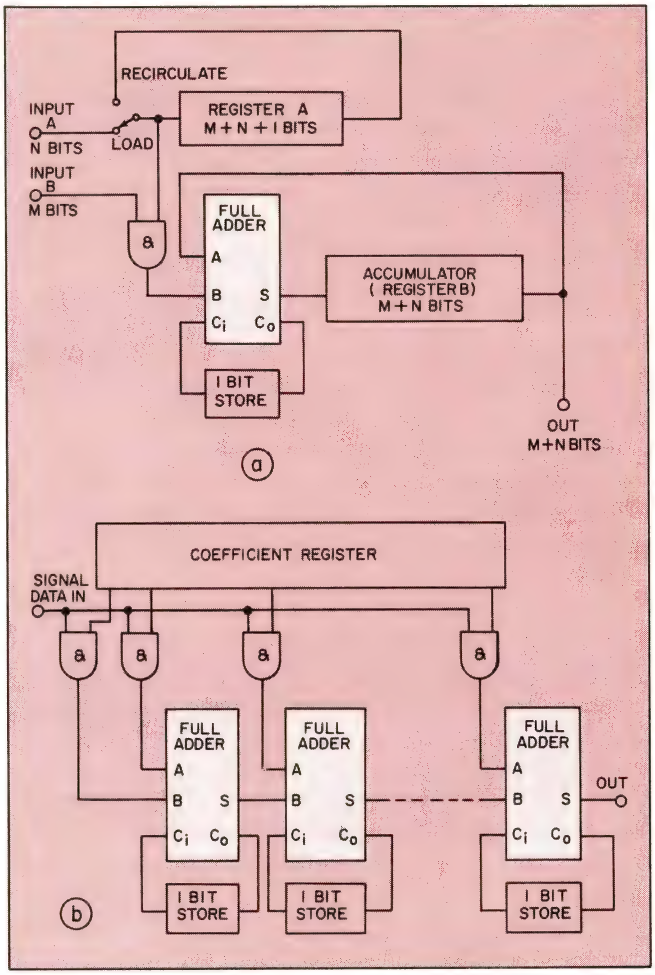
$$Y = \sum_{i=0}^{m} 2^{-m+i} (y^{i-1} - y^{i}),$$

where $(y^{i-1} - y^{i})$ represents the adjacent-bit pairs.

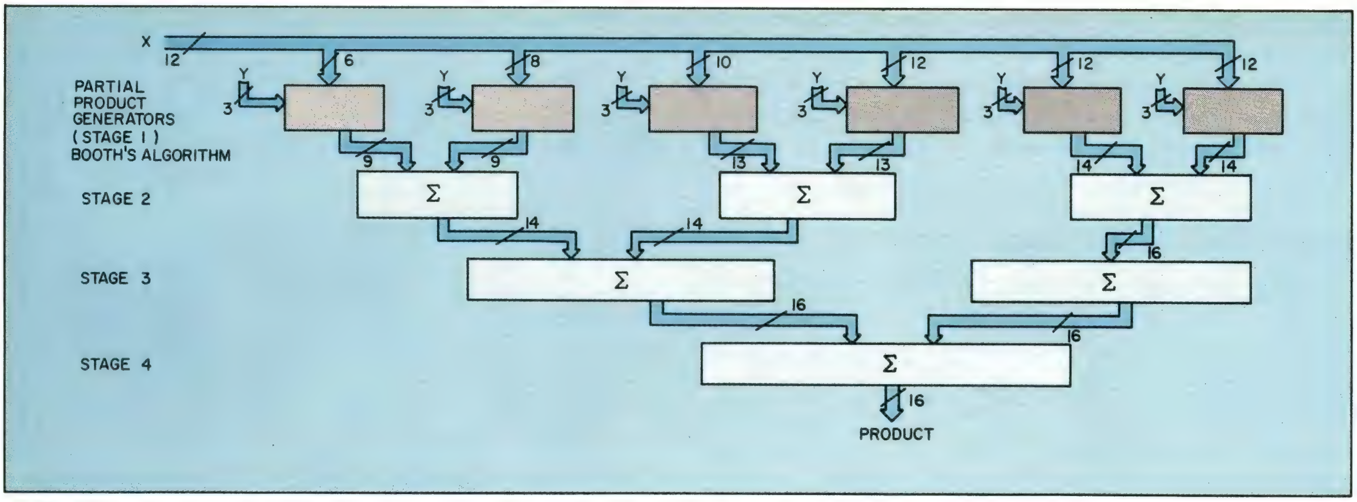
Each pair can assume four different binary configurations, or values (F_i). Starting with the least-significant pair, and multiplying each value of F_i by a number, X, produces four partial products, P_i. Then, by shifting Y one bit at a time, successive Y bit-pairs can be similarly multiplied by X. The total product


OUT
SIGNAL
IN
SIGNAL UPDATE REGISTER
SIGNAL – DATA MEMORY (RAM)
COEFFICIENT – DATA MEMORY (RAM/ROM)
ARITHMETIC UNIT
MULTIPLIER(S) AND ACCUMULATOR(S) (ASU)
ADDRESSES
AU CONTROL
INSTRUCTION MEMORY AND SYSTEM CONTROLLER (INSTRUCTION DECODE)

2. The multiplier and accumulator can be multiplexed and RAMs used to store (and thus provide delays) for the data, as in this generalized block diagram of a signal processor. ROMs and RAMs provide storage for coefficients and instructions.



3. A serial multiplier requires the least amount of hardware, but it's slow (a). The combination serial/parallel approach, called pipelining (b), is much faster.



4. Employing Booth's algorithm to perform the multiplication, the S2811 operates with three bits at a time and sums the partial products.

is obtained when all the partial products are summed:

$$XY = \sum_{i=0}^{m} 2^{-m+i} P_i.$$

Booth's algorithm is not limited to working with bit pairs. (Using pairs merely helps simplify the explanation of the algorithm.) Operating with three successive bits and then shifting twice per 3-bit group, as is done in the SPP, doubles the speed. In this way, the SPP multiplies two 12-bit two's-complement numbers in just 300 ns to get a 24-bit output. The numbers are separated into six substrings of 3 bits each, and each string executes Booth's algorithm individually. The partial products generated by the algorithm are then summed into a final 24-bit product.

Because the SPP operates primarily with 16-bit numbers (except at the multiplier input), the 24-bit product is not actually produced, but a minimum-logic circuit provides an accurately rounded-off 16-bit output.

Because the 16-bit words represent fixed-point, two's-complement fractional numbers in the SPP, the numbers require proper scaling to realize full accuracy. However, this procedure has the advantage that the multiplier cannot overflow.

On the other hand, the adder/subtractor can overflow. Arithmetic overflow causes highly undesirable behavior, especially when implementing recursive filters: The nonlinear overflow characteristics can cause oscillations because of the overflow's cyclic properties. To prevent such problems, the S2811 provides programmable overflow protection in its adder/subtractor unit. When an overflow is detected, the circuit substitutes a "saturation" value for the actual value, thus preventing oscillations.

Word length determines the maximum point of overflow and thereby establishes not only a digital filter's dynamic range but also its signal-to-noise ratio. However, as a practical matter, the word length is usually fixed by the microprocessor that implements the filter. The 16-bit word used in the S2811 has been found to be adequate for most ordinary purposes.■■

Booth's algorithm for multiplication

For multiplying an (m+1) bit word, Y, by X,

$$X \cdot Y = X\left[-(y^m) + \frac{y^{m-1}}{2} + \frac{y^{m-2}}{4} + \frac{y^{m-3}}{8} + \ldots \frac{y^0}{2^m}\right],$$

when the y terms are in two's complement notation. If the y terms are taken two at a time, the product becomes

$$X \cdot Y = X \sum_{i=0}^{m} 2^{-m+i}(y^{i-1} - y^{i}).$$

The y numbers can have the value of a one or zero only, and the most-significant bit, $-(y^m)$, represents the number's sign. When it equals one, the number is negative; when it's zero, the number is positive. The second bit, $y^{m-1}/2$, has the weight of 1/2, and $(y^{m-2}/4)$ has 1/4, etc. (Negative exponents of y are dropped.) Thus, the two's-complement number 1.0011, in ordinary binary, is −0.1101, or −13/16.

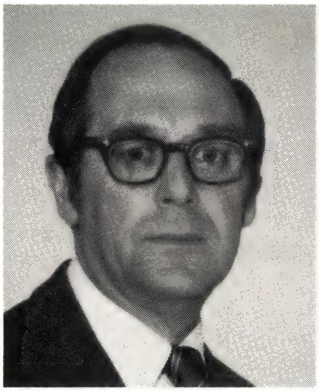
Taking two's-complement bits, two at a time, provides four possible combinations for each pair as shown in the following table, where $F_i = y^{i-1} - y^i$ and P_i is a partial product:

y^{i-1}	y^i	F_i	P_i
0	0	0	0
1	1	0	0
0	1	−1	−X
1	0	1	X

The partial product of each pair is shifted one bit to the left successively for increasing values of i and all are summed to yield the total product.

How useful?	**Circle No.**
Immediate design application	**559**
Within the next year	**560**
Not applicable	**561**

TANTALUM TECHNOLOGY: CAN IT GIVE US MORE CAPACITORS PER POUND?



Dr. John Piper
Manager of Research and Development
Electronics Division
Union Carbide Corporation

The recent escalations in the cost of tantalum materials concern everyone who must pay more for tantalum capacitors. The situation is very similar to the oil crunch and automobiles.

In both cases, the true supply situation is distorted by spot shortages and speculation. Potential substitutes for cars or tantalum capacitors are often discussed but, in reality, are quite unattractive. The intelligent way out is through more exploration, expanded production and greater conservation.

Conservation—more capacitors per pound of tantalum—is where KEMET® Capacitor's R&D will make its biggest impact. We have, in fact, surprised ourselves by making in the lab solid tantalum capacitors with conventional KEMET Capacitor quality, but using only a fraction of the tantalum. The tantalum savings are so great, they largely offset the cost increases of materials during the last two years.

Now, the job is to get this innovation out of the pilot plants, into production, and on to you. We are in an excellent position to do the job, because we have both KEMET Capacitor's own extensive research, development and engineering staffs, plus the vast technical resources of Union Carbide Corporation backing us up.

KEMET technology is proud to play a major role in easing the tantalum crunch. Our work, together with expanded production and new mineral exploration, will assure you of a continuous supply of quality KEMET solid tantalum capacitors to meet your highest performance requirements at a reasonable cost.

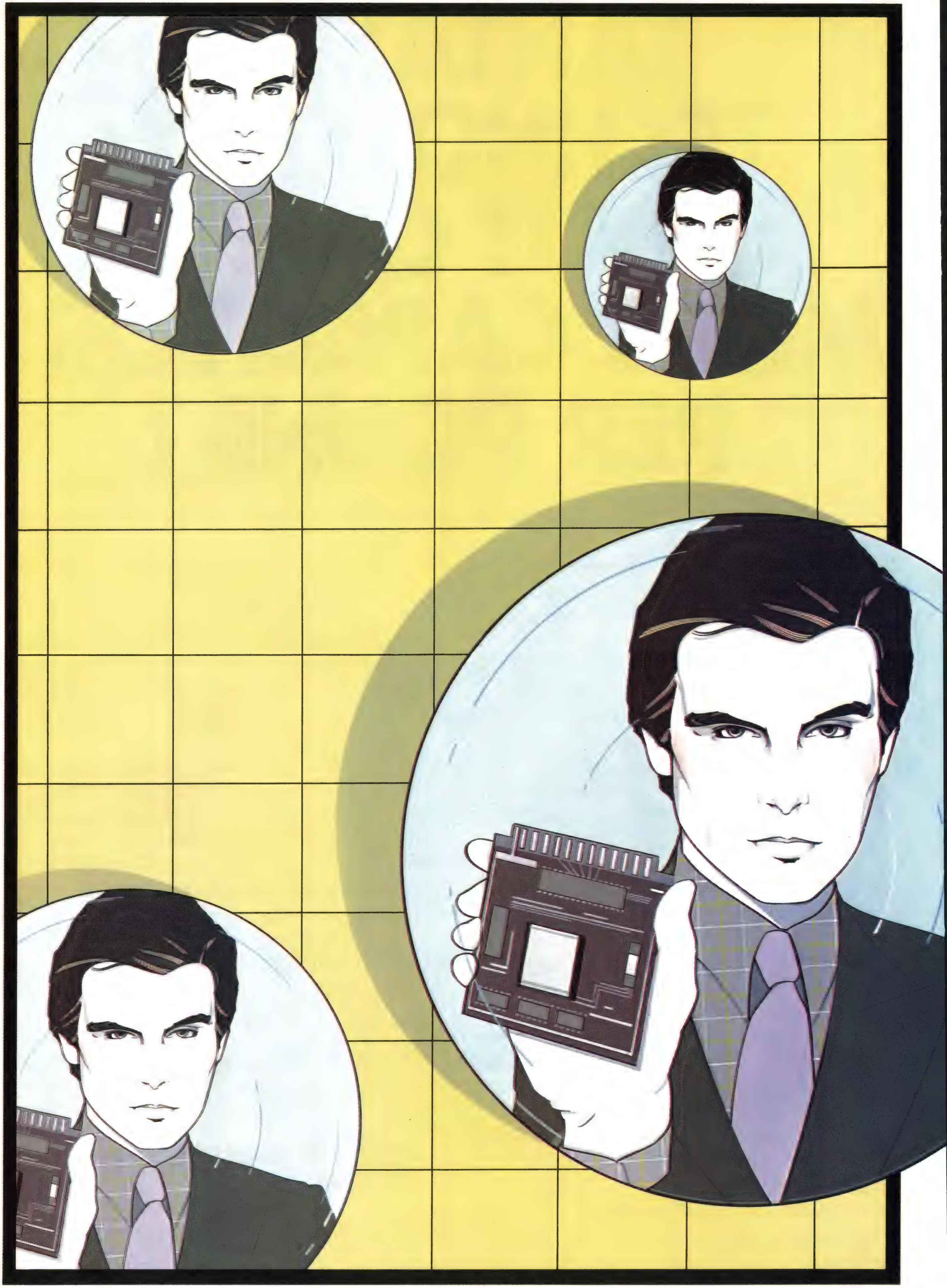
That's our commitment to you.

John Piper

UNION CARBIDE

ELECTRONICS DIVISION
COMPONENTS DEPARTMENT

Box 5928, Greenville, SC 29606
Phone: (803) 963-6300; TWX: 810-287-2536; Telex: 57-0496
In Europe: Union Carbide Europe, S.A. 5, Rue Pedro-Meylan, Geneva 17, Switzerland. Phone: 022/47 4411. Telex: 845-22253.
Union Carbide U.K. Limited Phone: 0325 315181
KEMET is a registered trademark of Union Carbide Corporation.



Million Bit Memory Kit

Intel delivers the first megabit bubble system and all the support you need to start designing today.

Step into the megabit bubble. You'll find an entirely new class of non-volatile storage—and vast new opportunities to exploit the microcomputer.

Bubble memory for microcomputers

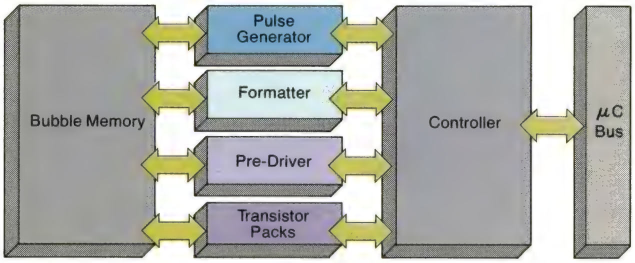
System designers have always been attracted to bubble memory for compact, low power, high reliability applications. Until now, though, bubble memories have been difficult to use and costly, since they require complex address, control and interface circuitry.

Today, Intel introduces a million bit bubble system perfectly matched in size and performance to the world of microcomputers. Intel's bubble memory gives you 128K bytes of low power read-write memory, plus all the system components you need for compatibility with advanced microcomputers like our 8-bit 8080, 8085 and 8088 and our 16-bit 8086.

Our system makes it simple

To simplify designing and manufacturing, Intel's bubble memory system consists of only seven components. All of them fit easily on a pc board as small as 4″x4″.

The heart of the system is our 7110 Magnetic Bubble Memory chip. It interfaces directly with our 7242 Formatter/Sense Amplifier, 7230 Current Pulse Generator, 7250 Coil Pre-Driver and two 7254 Quad Transistor Packs.



Intel® Bubble Memory System

The user interface, system timing and control functions are provided by our 7220 Controller, available Q1, 1980, or by our Controller Emulator Kit CPK-72, here today.

For systems exceeding a megabit, you can design with the same component family. Since one 7220 Controller will accommodate up to eight megabit chips and their support devices, larger system designs are simplified dramatically.

Bubble you can believe in

Intel's bubble memory means unparalleled data integrity. It's a rugged, solid state device. And it's completely non-volatile, so your data remains when the power goes off. No battery backup is necessary.

But the bubble system goes even further to ensure reliability. Intel's megabit chip works with the 7242 Formatter to give your system built-in error correction and detection. The 7110's ECC detects and corrects burst errors.

Start designing today

Intel's megabit bubble memory system is an ideal solution for microcomputer-based instrumentation, terminals, process controls and telecommunication systems. Everything you need to start designing is here today. Build your own system with our bubble memory prototyping kit. It gives you all the components for a one megabit system, plus complete documentation for easy designing. Or get a head start with our ready-to-use development board with complete system software. For a copy of our Bubble Memory Design Handbook, contact your local sales office or distributor. Or write Intel Corporation, Literature Department, 3065 Bowers Avenue, Santa Clara, CA 95051. Or call (408) 987-8080.

intel® delivers.

Europe: Intel International, Brussels, Belgium. Japan: Intel Japan, Tokyo. United States and Canadian distributors: Arrow Electronics, Alliance, Almac/Stroum, Component Specialties, Cramer, Hamilton/Avnet, Harvey, Industrial Components, Pioneer, Wyle/Elmar, Wyle/Liberty, L.A. Varah and Zentronics.

CIRCLE NUMBER 53

Finally... a value commitment to power you can rely on.

It's here **now** in C-Mod™...new customized multi-output modular power systems with all the pluses.

Finally, you have a real answer to your specialized power needs. Plus...

Value that goes beyond price and specifications to performance. Plus...

A Commitment to perform that goes beyond product. Plus...

Power, any way you spec it, to enhance your equipment's performance. Plus...

Reliability that comes from over 43 years of telecom power design and manufacturing experience.

Send for C-Mod information today. Lorain Products Corporation, 1122 F Street, Lorain, Ohio 44052. Or call (216) 288-1122.

LORAIN PRODUCTS
A RELIANCE ELECTRIC COMPANY
FIRST by Design

CIRCLE NUMBER 54

PC-connector performance can glitter with gold—Testing shows how

The optimum price/performance characteristics of a PC connector relate closely to gold usage and can be determined through testing. A considerable savings results from specifying only the exact plating thickness necessary for gold-plated card-edge connectors. Gold can be completely replaced in connector contacts but only at a sacrifice of durability and reliability (see "Gold shines as a connector material—at a cost").

Testing prevents overspecifying; it predicts what thickness of plating will meet performance indices. Performance tests should reflect the actual use of the connector. For example, evaluation for salt spray, industrial gas and other abrasive substances is necessary for a severe environment but not for a relatively clean one. Furthermore, connectors must survive repeated mating/unmating cycles, while maintaining low contact resistance. Of all the characteristics of connectors, their durability is most often overspecified, sometimes by hundreds of cycles.

Easy ways to overspecify

A typical computer-system connector, with 30 μin. of gold plate on the contacts, will operate reliably throughout 500 mating/unmating cycles, which may be overkill: Most PC boards rarely see more than 45 cycles in their lifetimes. However, a prototype system, which is mated and unmated whenever a new test or adjustment is made, might very well see 500 cycles. Therefore, the prototype system might call for 30 μin. of gold, but the production system needs just 10 to 20 μin.

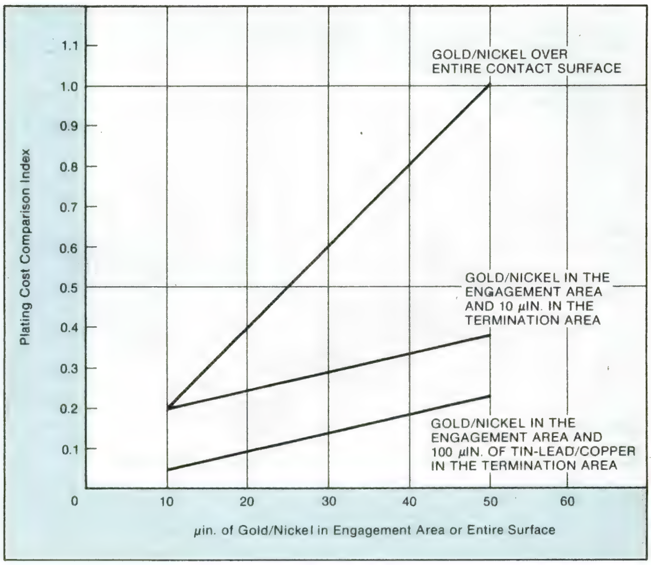
Similarly, if the equipment will operate in a well-controlled, air-conditioned environment, 15 μin. of gold may suffice. But if the equipment is located in a textile factory, lumber mill or oil refinery, then 30 to 50 μin. of gold on the contacts would better prevent corrosion of the electrical engagement surfaces.

Fig. 1 illustrates the relationship between durability, sulphur-dioxide resistance and the thickness of gold. As the figure indicates, plating thickness should increase only as the number of mating/unmating cycles or the corrosiveness of the environment increases.

Although most electronics applications call for minimal connector contact resistance, this factor becomes critical only in those applications involving very small voltages and signal currents. Gold is among the lowest in contact resistance of all precious metals; its re-

Gold thickness, μin. (electrical engagement area)	Sulfur dioxide resistance	Durability, mating/unmating cycles
10	Fair	100
15	Fair	150
20	Good	200
30	Excellent	500
50	Excellent	500+

1. Thicker gold plating on connector contacts increases their durability and resistance to contaminants, such as sulphur dioxide.



2. Plating costs vary linearly with gold thickness. A 30-μin. plating over the entire contact, for example, will cost 60% of a 50-μin. plating.

Sam Langham, Vice President of Engineering, Viking Connectors, Inc., Chatsworth, CA 91311.

sistance is somewhat independent of the plating thickness, varying only slightly in the range of 15 to 30 μin. The designer, therefore, should not overspecify plating thickness in an effort to reduce contact resistance. Other factors must be considered.

Checking it out

In-house testing reveals how different connectors and materials respond to common or unusual environments; for example, by changes in contact resistance. In specifying a connector, it may also help to know the engagement/separation force required for each connector contact, as well as the total mating/unmating force for an entire row of contacts (as in a card-edge connector).

Contact engagement and separation forces, connector mating/unmating forces and contact resistance at high and low currents are measured at room temperature. An (Instron) force-vs-displacement tester measures connector engagement forces and contact durability. Tests of contact resistance require a multipurpose millivoltmeter and a power supply: Current is passed through the fingers of the PC board and the connector contacts; then the voltage drop is measured and resistance is calculated.

For example, contacts selectively plated with 50, 30 and 20 μin. of gold, on a large card-edge connector with 144 dual contact points, are separated into two equivalent groups and tested for the above factors. The first group of connectors is then retested twice: after being subjected to 350 mating/unmating cycles and after being subjected to salt spray, per MIL-STD-202, method 101, condition B. The second group is retested after being subjected to industrial gas for 240 hours in a closed chamber with 10% sulfur gas by volume. Table 1 shows the average readings resulting from the four sets of tests.

The differences between plating thicknesses become most significant where the connectors will be subjected to harsh environments, such as salt spray (i.e., near a sea coast or on shipboard) or in an industrial environment. The low-level contact resistance, here, seems to increase slightly under these conditions. As the table indicates, for salt spray, the thinner the plating, the greater the increase in contact resistance.

Testing indicates how well different thicknesses of gold perform in the connector contacts. However, price/performance valuations of PC connectors are also necessary. Fig. 2 compares the contact plating cost for different contact finishes of gold to the cost for other plating materials (per 1000 units). The reference index number 1.0 is assigned to the standard plating cost per 1000 contacts that have 50 μin. of gold over their entire surface. The plating cost index for other contact finishes is obtained by dividing the cost for the 50 μin. reference into the plating cost per 1000 units of the other finish.

Putting gold where it's needed

Selective plating also helps to reduce costs by eliminating gold wherever and as much as possible. Table 2 compares the cost advantages of different plating techniques (assuming $400/oz gold).

Regardless of the contact finish, the base metal for the connector contacts can be berylium-copper, phospher-bronze or other copper alloys. In all cases, nickel is deposited over the base metal, prior to gold plating. The nickel prevents the migration of the base metal to the surface of the gold plate. Such migration would contaminate the gold and degrade performance.

Table 1. Mating forces and contact resistance under environmental tests

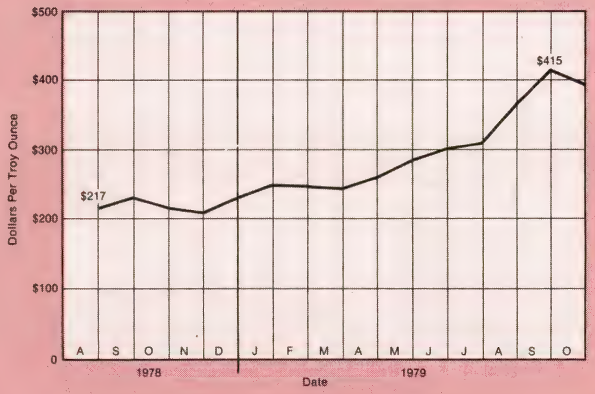
Test Description	Individual contact engagement and separation forces (oz)						Connector mating and unmating (blade) (lb)						Connector mating and unmating (PC board) (lb)					
	50 Gold		30 Gold		20 Gold		50 Gold		30 Gold		20 Gold		50 Gold		30 Gold		20 Gold	
	Eng.	Sep.	Eng.	Sep.	Eng.	Sep.	M	U	M	U	M	U	M	U	M	U	M	U
Initial readings of test groups 1 and 2	7.11	2.50	7.57	2.90	7.10	2.61	10.20	3.2	10.5	3.70	10.40	4.00	20.30	8.30	23.50	8.30	23.80	8.30
Readings after durability (350 cycles)—test group 1	6.90	2.89	7.06	2.95	6.70	2.82	9.70	3.0	10.0	3.30	9.50	3.70	19.50	7.60	20.40	8.10	19.00	8.30
Readings after salt spray—test group 1	6.96	2.78	7.50	3.02	7.44	2.66	9.50	3.5	10.1	4.10	10.30	4.30	17.00	7.70	19.00	8.30	18.10	8.40
Reading after industrial gases—test group 2	6.91	2.40	7.61	2.60	7.42	2.81	10.1	4.00	10.80	4.40	10.60	4.50	18.58	8.18	19.40	8.23	19.30	8.15

M = Mating
U = Unmating
50 = 50 μin. min. average gold
30 = 30 μin. min. average gold
20 = 20 μin. min. average gold

Gold shines as a connector material—at a cost

Because it resists oxidation and tarnishing and conducts extremely well, gold is the most desirable material for connector contacts. It resists corrosion and tarnish from chemicals usually found in hostile environments: nitric acid, hydrogen sulfide, sulfur dioxide, chlorine and ammonia. Its extremely low contact resistance makes it ideal for very small signals, though it also conducts high voltages and currents with good resistance stability over time. Its low coefficient of friction allows manageable mating and unmating forces. Because it can be deposited by several different means, gold is a versatile contact material.

Unfortunately, rapid price increases over the past five years have forced engineers to conserve gold. When gold cost $35 a troy ounce in the late 1960s, it had little effect on connector prices. Then the U.S. allowed the price of gold to float, and it did—upwards. Already the price of gold has exceeded $800, causing concern among connector users and suppliers alike. With gold contributing 62% to the cost of a typical connector, its impact on the cost of a system is now significant (see chart).



The designer faces the problem of specifying the gold content in PC-connector contacts in a prototype system without being able to anticipate the costs at the production stage. Selective plating, inlay and dotting techniques help to reduce gold consumption by putting the gold only and exactly where the electrical contact is made. However, the designer must still exercise judgment in determining just what plating thickness should be used.

In some cases, a hard gold is plated over a soft gold, which is plated over the nickel. This combination improves contact performance, but increases the cost of the connector.

Probably the most widely-used technique to reduce gold usage is the selective addition of gold where the connector contacts touch the PC board (the electrical engagement area). The maximum thickness of gold is applied where it can do the most good, and thinner

Low-level contact resistance (mΩ)			Contact resistance (mΩ)		
50 Gold	30 Gold	20 Gold	50 Gold	30 Gold	20 Gold
12.00	12.00	12.12	7.82	7.75	7.88
12.65	12.52	12.68	7.83	7.80	7.83
12.86	13.26	13.52	8.07	7.83	7.87
13.88	13.68	13.71	8.62	8.30	8.61

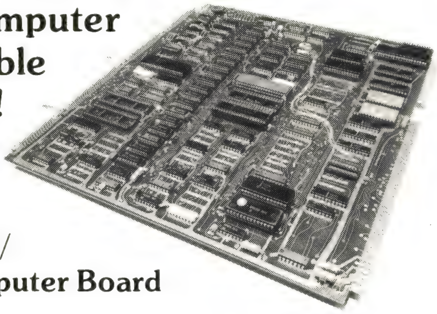
Table 2. Relative cost savings (to 30 μin. over entire surface at $400/oz)

Plating description	Cost saving per connector	% saving	Total savings for 300,000 connectors/year
20-μin. gold over entire contact surface	$1.07	23	$321,000
30-μin. gold in the engagement area and 10-μin. gold on the termination tail	$1.75	38	$525,000
20-μin. gold in the engagement area and 10-μin. gold on the termination tail	$1.93	42	$579,000
30-μin. gold in the engagement area and tin on the termination tail	$2.62	57	$786,000
20-μin. gold in the engagement area and tin on the termination tail	$2.80	60	$840,000

INTEL MULTIBUS USERS

Introducing

The Most Complete Microcomputer Available Today!

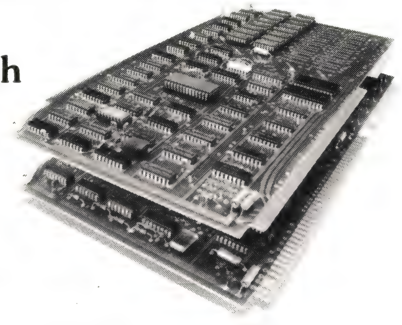


TCB-85/
Total Computer Board

One Board Does It All. . . This powerful single-board microcomputer uses the Intel 8085A CPU and is capable of supporting CP/M and **PASCAL**.

Compatible with Intel's Multibus, the TCB-85, combines an impressive variety of features: 64K Memory, Dual-Density/Double-Sided Floppy Disk Controller, Programmable CRT Controller with up to 80 ASCII or custom characters by 25 lines, Serial I/O Port, Printer Interface and Strobed or Scanned Keyboard Interface.

A New High Resolution Graphics System.



SVB-80P/
Soft Video Board Prototyping Kit.

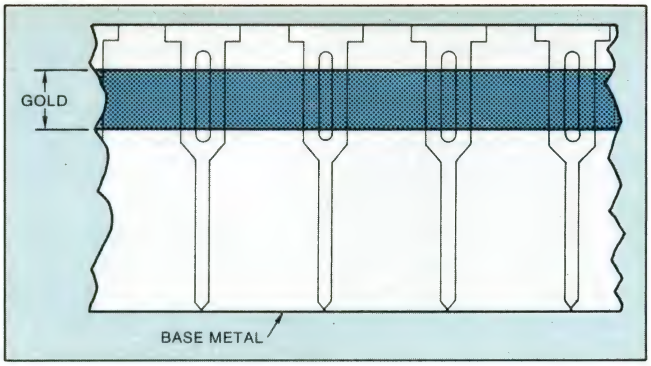
Featuring Dual-Board/Stand-Alone capability, this completely new prototyping package combines the SVB-80/Soft Video Board and the MIB-85/Memory Intensive Board in an Intel Multibus configuration. . .

The **SVB-80** displays 640 x409 or 576 x455 pixels, Alphanumeric characters displayed over 80 x40 or 72 x44 lines, Intermix of characters with graphics.

The **MIB-85** uses Intels's 8085A CPU with up to 32K PROM and 4K Static RAM, Programmable Keyboard Interface, Serial I/O Port, Programmable Interrupt Controller and Monitor Software to go "On-Line" immediately.

GET ALL THE DETAILS. . .Contact Alexander Newman at: (516) 621-6640

DOSC
OEM PRODUCTS DIVISION
175 I.U. Willets Road • Albertson, New York 11507
CIRCLE NUMBER 55



3. Strip plating before stamping wastes the gold between contacts. A gold retrieval process can add costly manufacturing steps.

gold is used elsewhere.

In one selective-plating method, called strip plating, gold is deposited continuously along the length of the base metal strip that makes the connector contacts (Fig. 3). The location of this added gold conforms to the portion of the contact in the electrical engagement area. Contacts are then stamped out of the base-metal strip and formed into the desired shape.

Gold can also be added after the contacts are formed from the base-metal strip. A continuous string of contacts is first stamped and formed from the metal strip; the contacts are held together at the bottom end by a continuous metal strip (called a carrier). Then, the entire contact (exclusive of the carrier strip) is gold plated. Afterward, only that portion of the contact in the electrical engagement area is moved through the plating bath, where additional gold is selectively deposited. Finally, the carrier strip is removed, leaving only the contacts.

Another selective approach is gold inlay. Here, the base metal strip is grooved and filled with gold. Contacts are then stamped and formed out of the strip.

Still another technique is to weld a gold dot in the electrical engagement area of the formed contact. The gold dot must be thick enough to be welded, so it is thicker and more costly than deposited gold.

Gold can be completely replaced by tin-plated contacts. To ensure a corrosion-free interconnection, this contact must provide high pressure perpendicular to the PC board. Its major advantage is its lower cost, but it has limited durability, usually less than 50 reliable mating/unmating cycles.

Combinations of tin and gold work well for the termination tail portion of PC board connectors. Tinned tails are solderable, so they present no reliability problem. Even in wire-wrapped connectors, the wrapping operation breaks through any oxidation on the tin-plated termination tail, providing a gas-tight joint.■■

How useful?	**Circle No.**
Immediate design application	**562**
Within the next year	**563**
Not applicable	**564**

Four very small ways Cutler-Hammer switches improve your PC design.

With four types of switches—rockers, pushbuttons, toggles and DIPs—we offer one of the industry's broadest and most unique selections of PC subminiatures.

Each of the hundreds of available styles provides the reliability you've come to expect from Cutler-Hammer switches. With ratings to 6 amps, each conforms to standard circuit board mounting requirements.

PC switches, along with accessories and decorative hardware, are distributor stocked for local availability. And since most are manufactured in the United States, we offer fast reaction time on solder lug and wire wrap terminal variations, as well.

To improve your next design in any number of small ways, contact your Cutler-Hammer Sales Office or Switch Distributor. Or write Eaton Corporation, Commercial Controls Division, 4201 N. 27th St., Milwaukee, WI 53216.

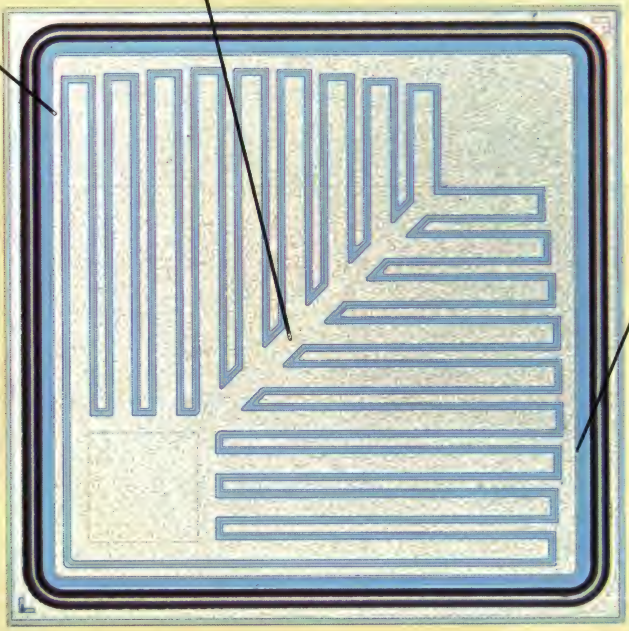
EATON
Electrical/Electronic Control

CIRCLE NUMBER 56

SGS-ATES.
Dimensions of
perfection in the universe of power.

A shining example.

BUX48



Computer designed geometry to optimize speed and $I_{s/b}$

Refined SGS-ATES Multiepitaxial structure to optimize $E_{s/b}$.

Quasi-planar base minimizes electrical fields on surfaces to assure optimum voltage ratings, thermal stability and reliability.

Family features

V_{CEO} 300 - 450 V	$E_{s/b}$ (Clamp) 10A at 450V
V_{CBO} 400 - 900 V	t_{on} and t_{fall} 200 ns at 10A/2A
I_C 15 (30 peak) A	$V_{CE\,(sat)}$ 0.3V at 10A/2A
P_D 125 - 175 W	

Complete range: BUX 48+

2N6546	BUW 44	BUW 46	BUX 14
2N6547	BUW 45	BUW 76	

BUX 48 and a complete family of mesa-multiepitaxial transistors from SGS-ATES for mains operated switching applications.

SGS-ATES has gained a position as a world wide authority in the field of switch mode power supply transistors. We produce a range of devices - both high voltage and high current, PNP and NPN, transistors and darlingtons - that covers every application, including both mains and battery. Not only the BUX48, but each member of the SGS-ATES switch mode power supply transistor range provides the best balance between speed, ruggedness, saturation and cost.

SGS ATES **Minute details matter.**

SGS-ATES Group of Companies - Italy: Via C. Olivetti 2 - 20041 Agrate Brianza - Tel: 039-650341/650441/650841 - Telex: 330131 - 330141 • Benelux: Winston Churchill Avenue 122 - B-1180 Brussels - Tel: 02-3432439 - Telex: 24149 B • Denmark: Marielundvej 46 D - 2730 Herlev - Tel: 02-948533 - Telex: 35280 • Finland: Kääntöpiiri 2 - 02210 Esbo 21 - Tel:90-881395/881396 - Telex: 123643 • France: 17 Avenue de Choisy - 75643 Paris Cedex 13 - Tel: 5842730 - Telex: 021-250938 • Germany: Haidling 17 - 8018 Grafing bei München - Tel: 08092-691 - Telex: 527370 • Hong Kong: 1329 Ocean Centre - Canton Road, Kowloon - Tel: 3-662625 - Telex: 63906 ESGIE HK • Norway: Stensberg gata 29 - Oslo 1 - Tel: 02-607222 - Telex: 17472 • Singapore: Lorong 4 & 6 - Toa Payoh - Tel: 2531411 - Telex: ESGIES RS 21412 • Sweden: Tingvallavaegen 9J - 19501 Märsta - Tel: 0760-40120 - Telex: 042-10932 • UK: Walton Street - Aylesbury, Bucks - Tel: 0296-5977 - Telex: 041-83245 • USA: 240 Bear Hill Rd. - Waltham, MA 02154 - Tel: 617-8906688 - Telex: 923495 WHA.

CIRCLE NUMBER 152

Motor serves as its own tachmometer when control circuit senses back-EMF

For precise speed control from a small dc motor, use the motor itself as a tachometer. A speed signal is obtained by feeding the motor a square wave and monitoring the back-EMF voltage during the "off" period. A simple circuit (see Fig.) can use this signal to control the motor's speed.

Alternative approaches to speed control—a tachometer or switching to a stepper motor—can be costly, in weight, volume, power or design time. The simple, inexpensive solution—using the motor itself as a tachometer—adapts to almost any low-cost dc motor. A handful of standard components can regulate speeds down to a few revolutions per second without any apparent feedback connection to the motor.

When operating, the dc motor develops a back-EMF directly proportional to its speed, and independent of the mechanical load. For the control circuit (see Fig.), a comparator is connected to the motor as a square-wave generator, controlling the buffer transistor Q_1 and power transistor Q_2. These transistors and the current-limiting resistor, R_5, are sized according to motor type and supply voltage. The motor is shunted by diode D_1 to avoid negative spikes. Motor noises are removed by the low-pass filter (R_1, C_1). Diode D_2 detects the level of the back-EMF. This is the speed signal. The reference signal is set by potentiometer P_1 (or any low-impedance voltage source).

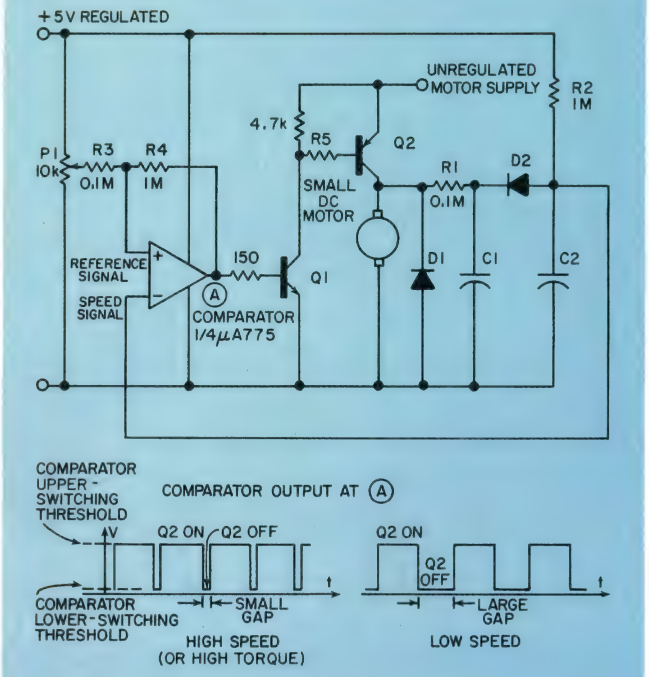
The dc motor is fed with constant-duration pulses, the on-time being determined by the R_2C_2 time constant. When the shaft loading increases, more pulses are generated per unit time, but they are always separated by a gap determined by $R_1(C_1 + C_2)$. This gap lowers the effective bias voltage, so the supply voltage must be increased slightly to stay above the stall torque. Overshoots in the pulse waveforms can create instabilities in the motor control loop. Increasing the value of R_1 stabilizes the system.

The accuracy of the speed control is not particularly sensitive to variations in the motor power supply. The speed is stable when the reference signal and speed signal are of equal amplitude. In the schematic, the reference signal is about 90% of the voltage derived from P_1. More accurate speed control can be obtained by reducing the ratio R_3/R_4, or by placing an integrator in the loop.

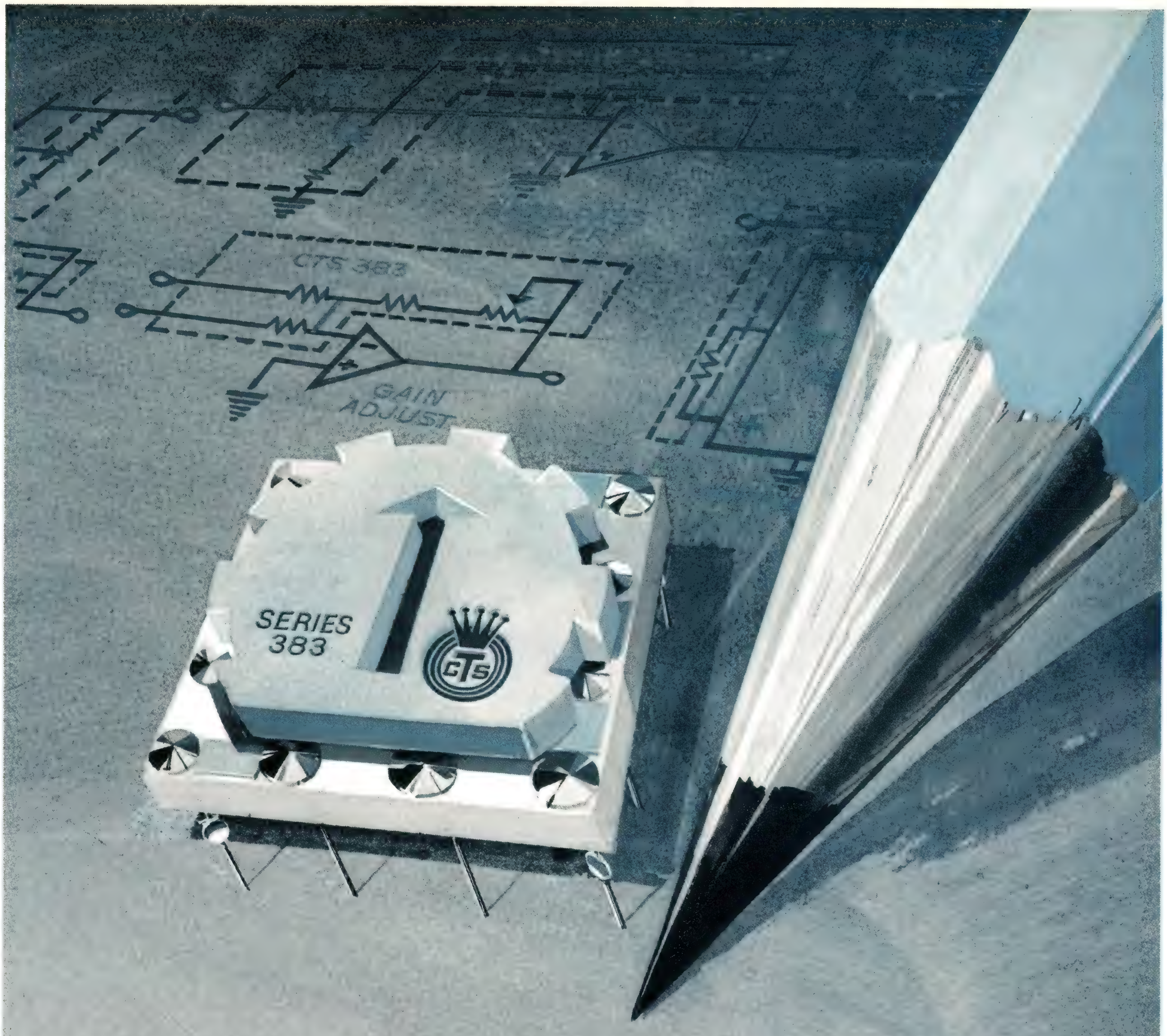
It is also possible to adapt this dc motor control technique to ac motors by separating the ac motor's stator and rotor windings. The speed of the ac motor is controlled by detecting the voltage envelope from the rotor windings during the "off" periods.

M. Do Mau Lam, Electronics Engineer, MATRA, 37 av. Louis Breguet - 78140 Velizy, France.

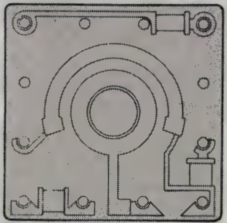
CIRCLE NO. 311



Back-EMF, sampled during "off" periods, allows a small dc motor to act as its own tachometer. Constant speed is maintained because, when shaft loading increases, more "power" pulses are generated per unit time.



Specifying both resistors and trimmers? Here's a single solution from CTS.



CTS proudly presents a single solution to many of the problems you face in specifying resistors and trimmers . . . the Series 380 thru 384 Cermet Resistor/Trimmer combinations.

Have Board Space Problems? The Series 384 offers you up to eight fixed resistors plus a trimmer in a .46″ square (.275″ high) package.

Need Hefty Power Capability? All units in this Series can handle one watt at 70°C and ¾ watt at 85°C.

Need Cermet Stability? ±250 ppm/°C is the standard temperature coefficient in this Series with ±100 ppm available for your critical needs.

Want Rock Bottom Prices? The Series 383 (shown above) provides you combinations of three fixed resistors plus a trimmer for only 35¢ in production quantities. The Series 380 trimmer only is priced under 25¢. This economical space saving form factor is available as a trimmer only, in resistor/trimmer networks, and as resistor networks only. Let the Application Engineer from CTS Microelectronics help you decide which Series is best for your design.

CTS MICROELECTRONICS, INC., 1201 Cumberland Avenue, West Lafayette, Indiana 47906. Phone (317) 463-2565.

CTS CORPORATION
Elkhart, Indiana
A world leader in cermet and variable resistor technology.

CIRCLE NUMBER 59

BiMOS control chip extends battery life in camera's photoflash circuit

Low standby current drain helps extend the battery life in portable consumer electronic products that must deliver only occasional bursts of power. The CA3164E control IC is a BiMOS chip that consumes less than 15 μA during standby; yet, it can provide 100 mA of chopped current to the dc-to-dc converter in an electronic photoflash circuit, during the energy-reservoir charging cycle.

In the photoflash application (Fig. 1), the CA3164E drives the primary of step-up transformer T1 with symmetrically chopped current at a 500 to 2000-Hz rate. The bridge-connected diodes, D1 through D4, rectify the output of T1 and charge the energy-reservoir capacitor, C3, to approximately 280 V. The maximum charge of C3 is determined by the voltage-divider ratio R2:R3. A tap between these resistors provides a turn-off signal to pin 2 of the CA3164E. LED D6 is energized while C3 charges.

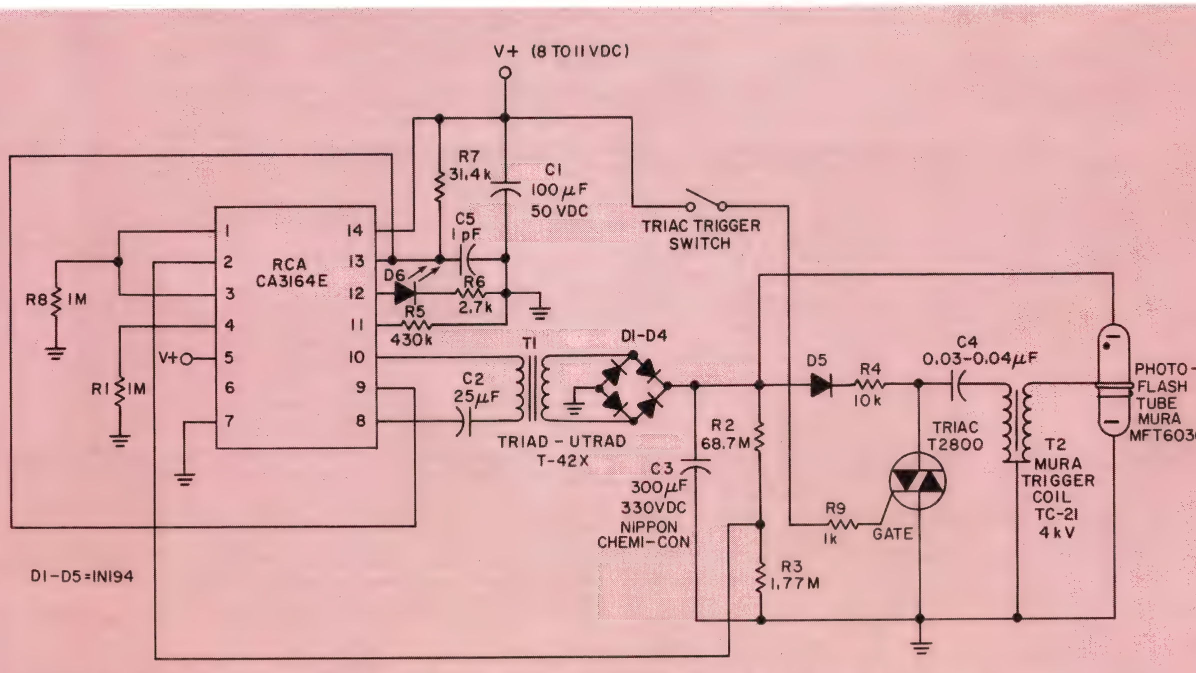
During the C3 charge cycle, capacitor C4 is also charged via D5, R4 and the primary of step-up transformer T2. When the manual triac-trigger switch (in the camera) is momentarily closed, the triac conducts and C4 is discharged through the primary of T2, generating a short 4-kV pulse across the secondary of T2. This pulse overcomes the ionization potential of the photoflash tube which, once fired, continues to draw current from reservoir-capacitor C3 until the charge is exhausted.

The CA3164E's chopper frequency, determined by R1, R5 and C5, is about 500 Hz with the components shown. The duty cycle is determined primarily by R7 and approximates 50% when R7 is 31.4 kΩ. Capacitor C3 recharges in about 20 seconds.

The bridge-type push-pull output of the IC can drive thyristors, transformers, speakers and piezo-electric transducers. The chip is suitable for many other consumer electronics applications: ionization and photo-electric smoke detectors, humidity alarms, remote wireless sensors, proximity switches and touch switches.

Carmine Salerno, Linear Industrial Applications Engineer, RCA Solid State, Route 202, Somerville, NJ 08876.

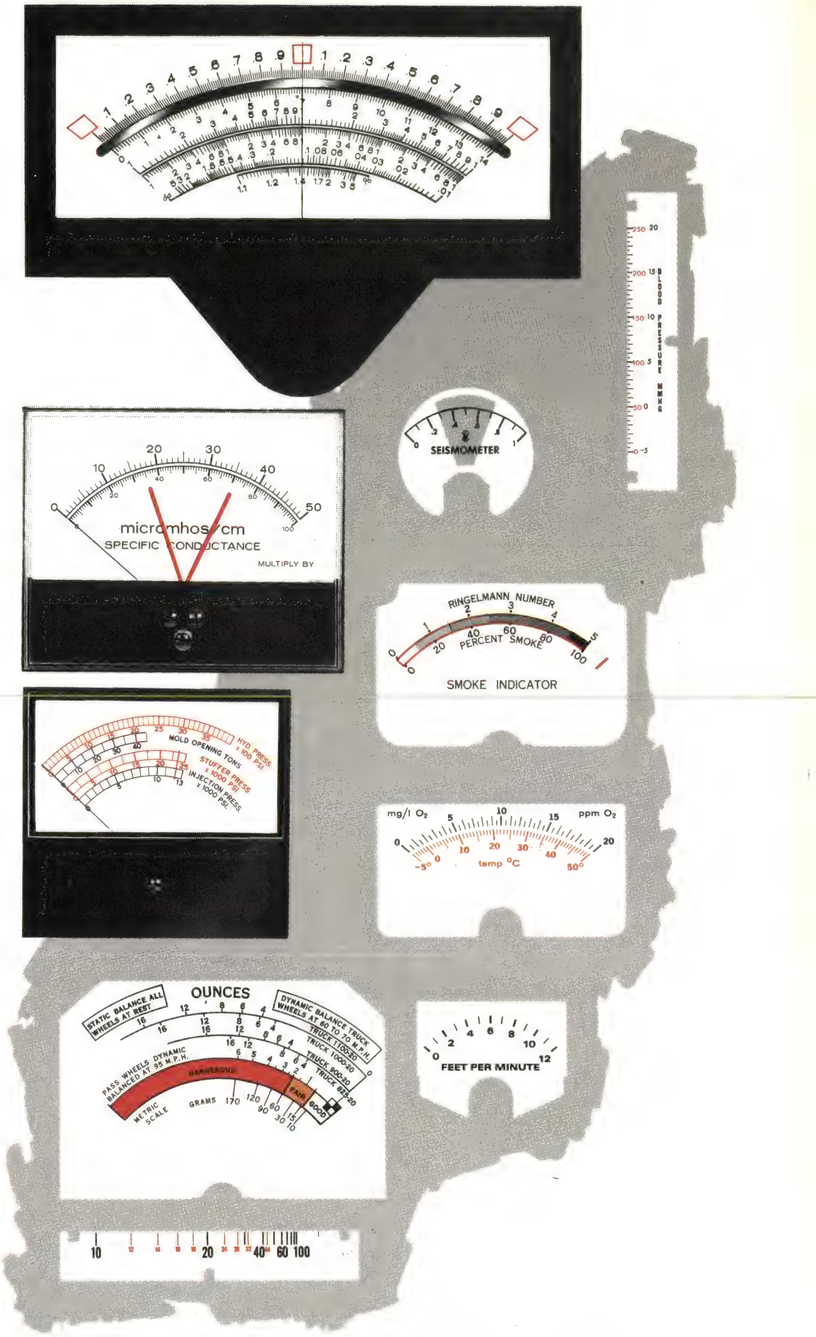
CIRCLE NO. 312



Because of its low current drain during standby, this electronic photoflash circuit prolongs the life of a camera flash battery. The LED (D6) blinks whenever the CA3164E is briefly activated to replenish the charge lost through leakage currents. The normal charging cycle takes about 20 seconds.

If you need panel instruments with custom dials, cases, accuracy, tracking, resistance, response time, or practically any combination of unusual specs...

Buy Triplett's designed-for-you Panel Instruments



Although we stock some 1369 different styles, sizes and types of standard panel instruments, a very large proportion of our customers buy custom instruments.

Because they need:

custom dials
: reading in such units as pH, roentgens, mm Hg, rpm, %, inches.

custom cases
: square, round, rectangular, edgewise (horizontal and vertical), wide, narrow, shallow.

custom accuracy
: to within ½% with mirror scales and knife-edge pointers.

custom tracking
: to match the specific needs of existing or new instrument designs.

custom resistance
: for low circuit loading with tolerances as low as ±1%.

custom damping
: to meet stringent electrical and vibration requirements.

For instance, one of our customer's had us design and manufacture a custom instrument to replace — in every detail of physical and electrical specifications — one which he was using on a delicate piece of medical instrumentation. Rejects from his previous source had risen to over 20%. He rejected only 3 of the first hundred we shipped—with almost negligible rejections from the many hundreds we've shipped since.

What custom panel instrument specifications do you need to make your product more reliable, more accurate, more rugged and — in the long run — less expensive? For quick, dependable delivery of small quantities of Triplett's "designed-for-you" panel instruments, contact your Triplett Sales/Service/Modification Center. For prototypes or production quantities, contact your Triplett representative. He'll put you in touch with our Instrument Designers/Engineers who'll help you analyze the problem and suggest the optimum cost/result solution.

TRIPLETT
BLUFFTON, OHIO 45817
Manufacturers of the World's most complete line of V-O-M's

CIRCLE NUMBER 60 FOR INFORMATION
CIRCLE NUMBER 61 FOR FREE DEMONSTRATION

Low-battery threshold detector draws only 2 μA of standby current

A complementary pair of MOS transistors can provide low-battery detection, drawing less than 2 μA. This small standby current will meet the special requirements of battery-powered equipment that is "on" all the time such as smoke detectors and intrusion alarms. Such equipment is turned on and forgotten, so it must be able to alert passersby when the batteries need to be replaced—but without significantly reducing battery life. The circuit uses two integrated circuits, an RCA CD4007A dual complementary pair and an RCA CD4049 buffer/inverter, along with several resistors, a potentiometer and an LED (see Fig.).

The voltage divider formed from R_1 and trimmer R_2 divides the battery voltage into a value close to the threshold voltage (about 2 V) of the CMOS pair, A_1. This puts A_1 in its linear operating region. Resistor R_3 limits the current in A_1 to less than 1 μA. The threshold voltage remains relatively constant with respect to changes in the 9-V battery supply voltage. As the battery weakens, therefore, the output of A_1 will go high when the input drops below the threshold (A_2 and A_3 act as buffers and supply both normal and inverted outputs).

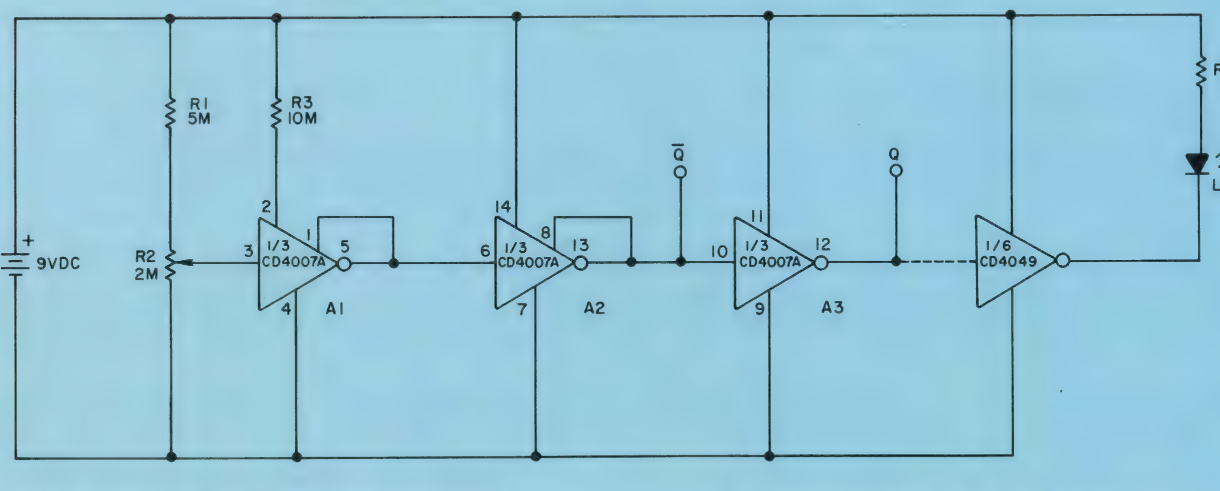
To set up the circuit, a voltage equal to the desired battery cutoff voltage is applied in place of the battery (6.5 V for a 9-V alkaline battery). Then R_2 is adjusted until Q goes high. By properly selecting R_1 and setting R_2, the circuit can detect any cutoff voltage that lies between the CMOS threshold voltage and the maximum voltage rating of the CD4007A CMOS pair.

The Q or $\overline{Q}$ outputs can be used to drive any compatible logic, such as a CD4049 buffer/inverter driving an LED.

Above the preselected cutoff voltage, the circuit will draw about 2 μA; below cutoff, about 5 to 10 mA (exclusive of the LED indicator current), depending on the battery voltage. The circuit exhibits a hysterisis of about 0.1 V.

Michael Rubinstein, Consulting Engineer, Research Dynamics Co., 206 27th St., Suite 301, San Francisco, CA 94131.

CIRCLE NO. 313



To set up this low-battery detector, substitute a desired threshold potential for the battery, then adjust R_2 until Q goes high. With a good battery in place, only 2 μA of standby current are consumed.

The case for CMOS crosspoints: Just these two RCA devices do the job of 48 relay switches.

If you're still using relays or high-current discrete switches in your telecommunications equipment, here are some good reasons to switch to RCA CMOS crosspoints.

With a single IC you can replace as many as 32 discrete switches, as well as the additional support circuitry normally needed for decoding and latching. This can improve reliability. Because the lower the parts count, the higher your reliability.

It also makes it possible for you to design much smaller products.

RCA crosspoint switches are available in three types. The CD22100, a device that combines a 4 to 16 decoder with a 4 × 4 array of crosspoints.

The CD22101 which combines a 4 to 16 decoder with a 4 × 4 × 2 array of crosspoints. And the CD22102 version which has a different input logic configuration.

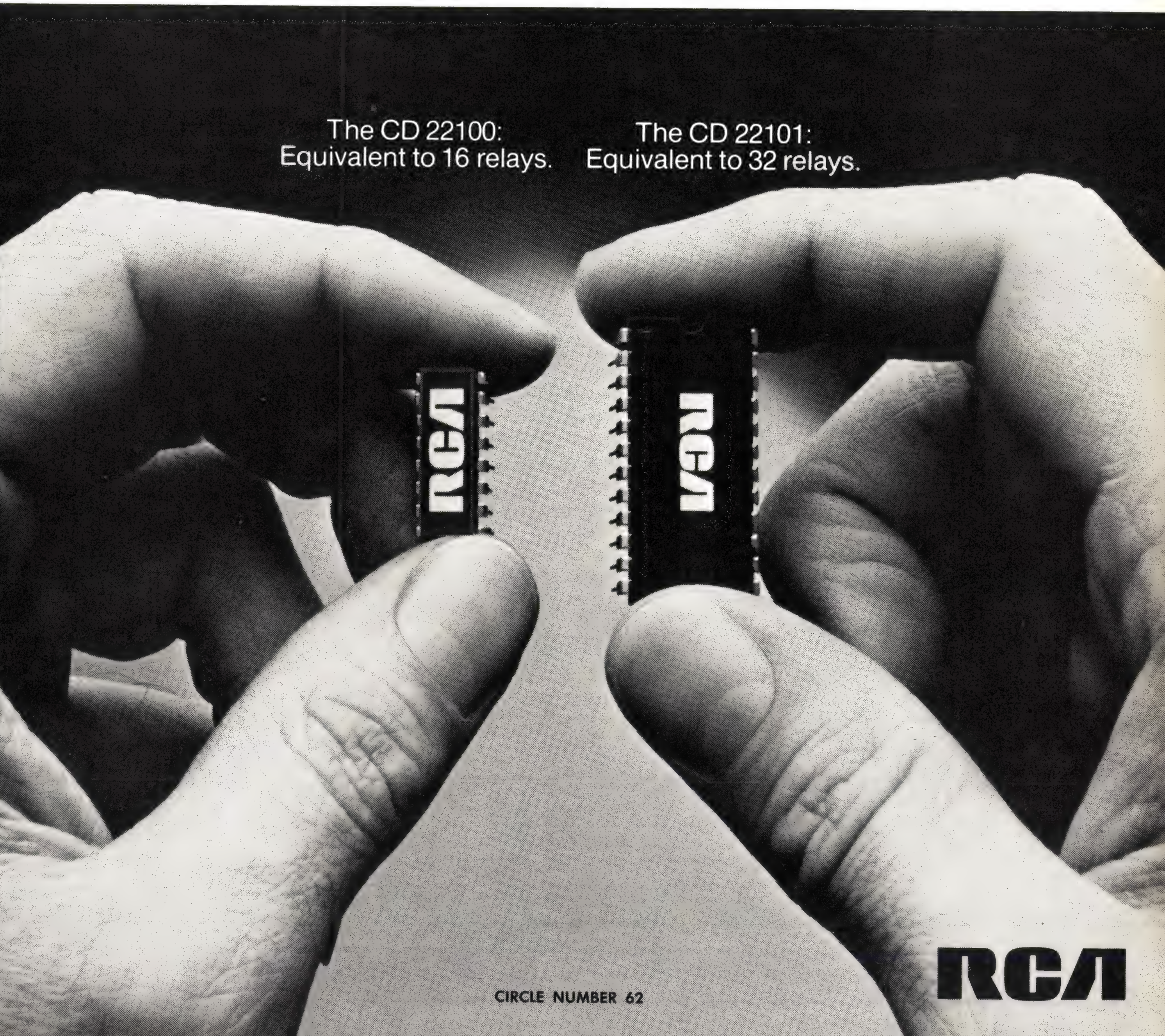
All three devices feature low on-resistance, built-in control latches, 10 MHz switch bandwidths.

Plus the low power consumption and high noise immunity associated with all RCA CMOS devices.

RCA crosspoint switches are available immediately for volume orders.

For further information, contact your local RCA Solid State Distributor.

Or RCA Solid State headquarters in Somerville, N.J. Brussels, Belgium. Tokyo, Japan.



The CD 22100:
Equivalent to 16 relays.

The CD 22101:
Equivalent to 32 relays.

RCA

CIRCLE NUMBER 62

Temp-sensor probe made from two ICs turns any DMM into a digital thermometer

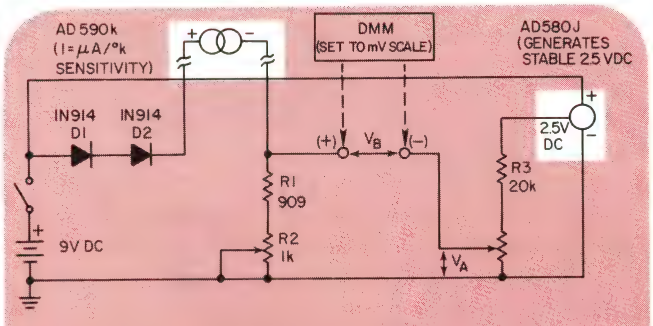
A temperature-sensor probe capable of $\pm 1\%$ accuracy and adaptable to almost every digital multimeter can be assembled from two inexpensive ICs and some standard-value precision resistors. In addition, direct readings on the DMM in either Celsius or Fahrenheit are easily obtained.

The circuit is built around the AD 590K, a current source whose output is proportional to absolute temperature, and the AD 580J, which provides an offset reference voltage to convert absolute temperatures to Fahrenheit or Celsius.

In the figure, the AD 590K serves as a temperature sensor probe, producing a current that is directly proportional to absolute temperature at the rate of 1 μA/°K from 218 K to 423 K (−55 to 150 C). A load resistance of 1000Ω $(R_1 + R_2)$ converts this current to a voltage (1 mV/°K) for Kelvin readings. Similarly, an 1800-Ω load will yield 1.8 mV/°K for Rankine readings (°R = 1.8°K).

For the DMM to read directly in °C or °F, the probe's output voltage must be offset for the conversion from absolute temperatures. Since Celsius readings equal Kelvin readings minus 273.15°, the 2.5 V from the reference voltage IC (AD 580J) must be attenuated to 273 mV by voltage divider $R_3 + R_4$. This offset voltage is subtracted from the sensor probe output voltage to give a final scale factor of 1 mV/°C. Similary, by setting $R_3 + R_4$ to yield 460 mV, the scale factor becomes 1 mV/°F for Fahrenheit readings.

Because the probe has a linear output characteristic, it may be calibrated from a single setpoint. Potentiometer R_4 is first adjusted to make V_A equal 273 mV for °C readings (or 460 mV for °F readings). Then a stable temperature bath is made from a well-stirred mixture of crushed ice and water. (Use just enough water to fill all voids between the ice chips.) The mixture should be prepared in an insulated foam container; it will come to equilibrium very close to 0 C (32 F) after about 15 minutes.



DMMs double as digital thermometers with the addition of this simple circuit. Probe accuracy of ±1% from −55 to 150 C (−67 to 302 F) is obtained after single-point calibration with a crushed ice/water mixture.

With the sensor probe totally immersed (be sure to insulate the leads), R_2 is adjusted to that V_B equals 00 mV (°C calibration) or 32.0 mV (°F calibration). The millivolt scale of the DMM will now read directly in °C or °F

A shielded cable is not needed due to the current output of the probe. Diodes D_1 and D_2 reduce the power dissipation in the probe sensor and minimize the resulting thermal effects. Conductive grease provides effective heat transfer between the sensor and test objects. The sensor's high isolation voltage rating (±200 V) allows live circuits to be probed.

William D. Kraengel, Jr., Electrical Engineer, 65 Sunset Rd., Valley Stream, NY 11580.

CIRCLE NO. 314

IFD Winners for October 25, 1979

Abe Abramovich, Member of the Technical Staff, and Thomas F. Lenihan, Senior Technical Associate, David Sarnoff Research Center, RCA, Princeton, NJ 08540. Their idea "Adapter Modifies a 2716 EPROM Programmer to Accept 2732s" has been voted the Most Valuable of Issue Award.

Vote for the Best Idea in this issue by circling the number for your selection on the Reader Service Card at the back of this issue.

SEND US YOUR IDEAS FOR DESIGN. You may win a grand total of $1050. Here's how. Submit your IFD describing a new and important circuit or design technique, the clever use of a new component or test equipment, packaging tips, cost-saving ideas to our Ideas for Design editor. Ideas can only be considered for publication if they are submitted exclusively to ELECTRONIC DESIGN. You will receive $20 for each published idea, $30 more if it is voted best of issue by our readers. The best-of-issue winners become eligible for the Idea of the Year award of $1000.

ELECTRONIC DESIGN cannot assume responsibility for circuits shown nor represent freedom from patent infringement.

Don't waste days, dollars and dBs reinventing Avantek modular amplifiers.

Complete pre-packaged 5-1000 MHz amplifiers available off-the-shelf.

Each Avantek modular amplifier is a wideband, hermetically-sealed, gain-block featuring flat response across RF and IF bandwidths greater than six octaves. If you're concerned with noise, sensitivity, dynamic range and distortion, these linear amplifiers fit the bill. Use them singly or cascaded as RF and IF stages in receivers, pre-amps, cable drivers, gain elements in multichannel power splitters and multicouplers, RF distribution systems, RF feedback loops, isolation and buffer stages.

No external circuitry required— prices less than $1.00 per dB gain.

Don't be fooled by other, lower-cost amplifiers which require the addition of external circuitry. Our tiny TO-12 packaged modules incorporate microwave transistor chips, thin-film ceramic circuits, thin-film resistors and chip capacitors. They eliminate the normal frustrations of in-house RF design, impedance matching networks, feedback loops, biasing and stabilization elements. These commercial amplifiers use the same high reliability Avantek transistors we developed for use in our military—aerospace amplifiers. We can also screen these amplifiers to MIL-STD-883.

General Purpose Cascadable Amplifiers, TO-12 Specifications @ 25°C

Min. Freq. Response (MHz)	Min. Gain (dB)	Typ. Noise Fig. (dB)	Typ. Power Output for 1 dB Gain Comp. (dBm)	GPD Model No.
5-200	30	3.5	+5	201
	25	5.5	+9	202
	25	4.0	+1	251
5-400	13	4.5	−2	401
	12	3.2	−6	411
	13	6.0	+6	402
	9	7.5	+15	403
	9	7.5	+15	404
5-1000	12	6.0	0	1001
	12	7.0	+6	1002
	10	8.0	+14	1003

Try one in your next design.

Send for data sheets and a copy of our applications manual, *Designing With GPD Amplifiers.* We also have units available off-the-shelf for evaluation. Write Avantek, 3175 Bowers Ave., Santa Clara, CA 95051 or phone (408) 249-0700.

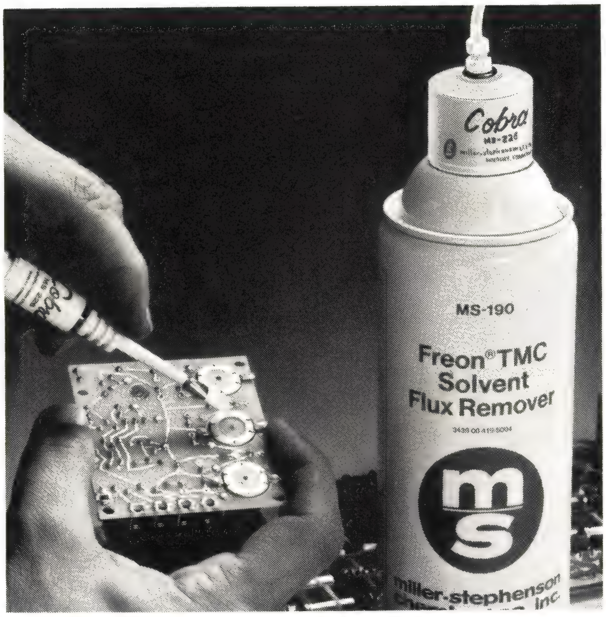
Avantek

© 1979 Avantek, Inc.
Avantek is a registered trademark of Avantek, Inc.

CIRCLE NUMBER 63

All electronic problems are

MS-180 FREON ® TF Solvent — High purity, low surface tension and fast evaporation. For critical cleaning of electronic components.


Cobra
MS-226
MS-190
Freon® TMC Solvent Flux Remover
ms
miller-stephenson chemical co. inc.

MS-190 FREON TMC Solvent — Fast cleaning action removes all types of organic flux.

FREON is Du Pont's registered trademark for its fluorocarbon compounds.

MS-165 FREON TMS Solvent — Outstanding for removal of activated rosin flux, ionic soil and particulate matter.

MS-176 FREON TES Solvent — Offers long term compatibility with reactive metals and other solvent-sensitive materials.

cleaning not alike...

That's why we offer 15 different solutions

MS-160 FREON T-P 35 Solvent — Excellent for precision cleaning and water film displacement.

MS-185 FREON TA Solvent — Stronger solvent action for oil film removal and other tough cleaning applications.

We've developed and perfected 15 different precise solvent cleaners. Miller-Stephenson spray cleaners are specially designed to meet the toughest kind of cleaning problems you'll encounter on printed circuit boards or any other electronic application.

For years we've recognized industrial cleaning as a vital link in maintaining component and system reliability. That's why we take every possible precaution to make sure that every Miller-Stephenson product has the lowest residual contamination in the industry — some approaching 5-7 parts per million. The general industry range is 50-130 ppm.

We use only the highest grade manufacturer certified solvents and nonflammable propellants and we *double filter* our solvents and propellants, first with a 5 micron filter, then with a Millipore 0.2 absolute filter. The filtered product goes directly into seamless cans, eliminating any possibility of flux contamination from seamed cans. We have complete quality control, from tanker to customer.

Send for free booklet...

To help you quickly and easily find the precise solvent cleaner for your particular application, we're offering a FREE booklet. Simply circle the Miller-Stephenson bingo card contained in this magazine — or write to us for your copy.

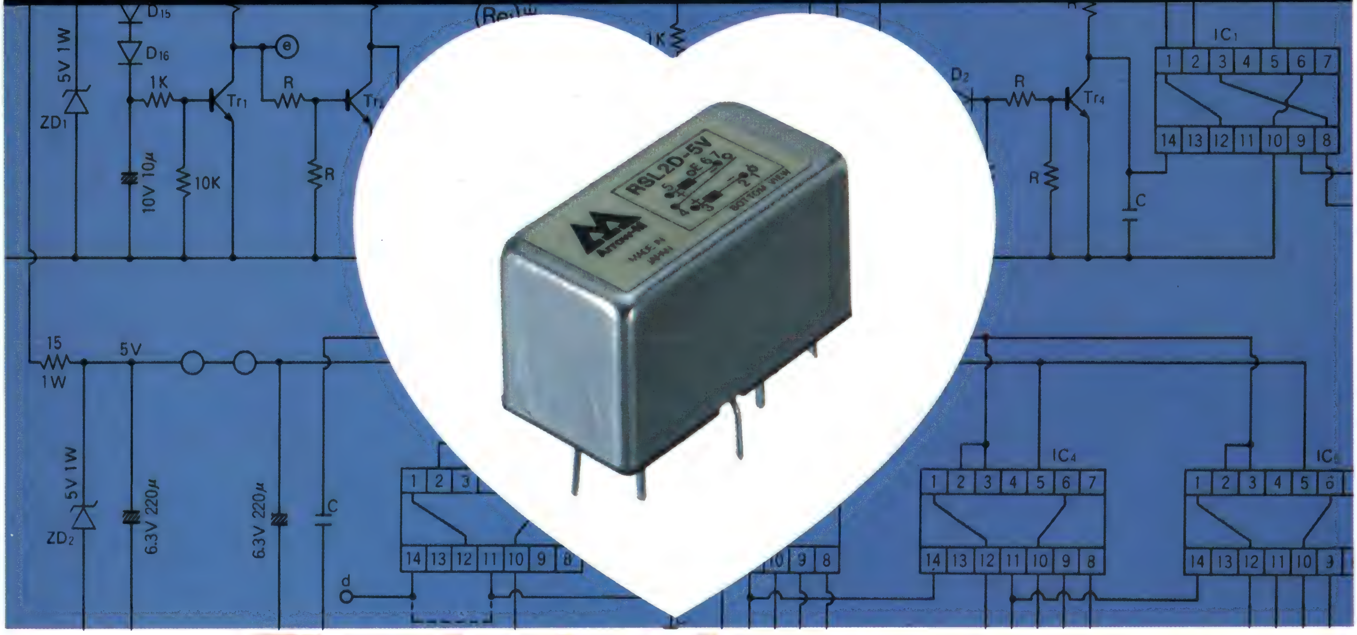
Purity, it's something we never forget!

miller-stephenson chemical co., inc.
George Washington Highway, Danbury, CT 06810
Phone: (203) 743-4447 ED-27

• LOS ANGELES • CHICAGO • TORONTO • DANBURY, CT.
WORLDWIDE DISTRIBUTION

CIRCLE NUMBER 64

Half-size Amber R Relays



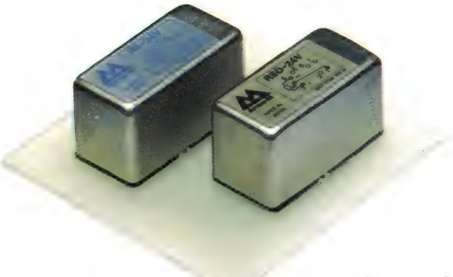
Thanks for the memory.

Latching function acts as a memory to protect the integrity of your program.

Half-size Amber R Relays latching types operate on alternate application of reversed polarity voltage. The stability of the memory is dependable at all times, retaining program integrity even during power failures.

- R Relays will switch 1 Ampere 20 watts and as low as 10 μ Amperes for over 1 million operations, and they will not weld even when carrying high inrush currents.
- The unique construction permits true Form C contacts in a reed type relay.
- High sensitivity: Minimum operating power. Latching type 40mW/Standard type 80mW
- Totally encapsulated for automatic wave soldering and cleaning.

More than 26 million R Relays in service around the world.



Relays for Advanced Technology

Aromat

Member of Matsushita Group

Contact Your Aromat Representative or Distributor Today.

Aromat Corporation:
250 Sheffield Street
Mountainside, NJ 07092
(201) 232-4260

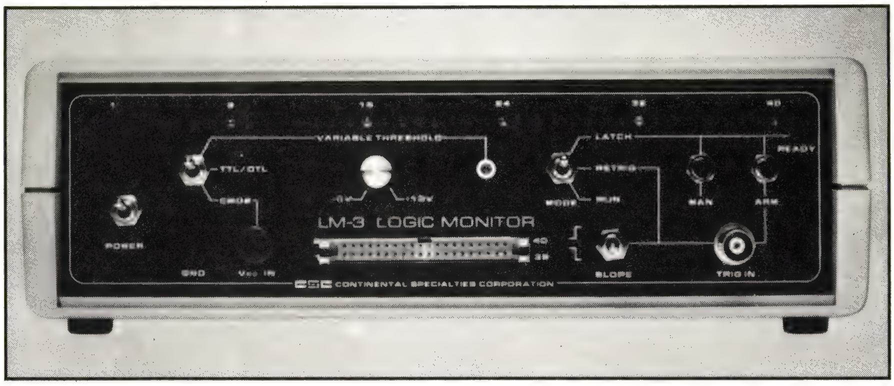
Mid-Western Office:
311 Lively Blvd.
Suite 1
Elk Grove Village, IL 60007
(312) 593-8535

Western Office:
10400 North Tantau Avenue
Cupertino, CA 95014
(408) 446-5000

43A

CIRCLE NUMBER 65

Logic-state indicator monitors 40 test points simultaneously



Continental Specialities Corp., 70 Fulton Ter., New Haven, CT 06509. Marty Weinstein (203) 624-3103. $585; stock.

For monitoring up to 40 test points at one time, the Continental Specialties LM-3 test instrument houses 40 triggerable, precision-threshold logic indicators. The turn-on threshold of each indicator adjusts for any logic family —TTL, DTL, CMOS, VMOS, ECL and I²L are a few examples—and supply voltage. A 40-LED display panel shows the status of each test point in four modes, which are selectable using a front panel control.

The LM-3's operating modes are: direct tracking of input data, latch on each trigger, latch only on the first trigger or latch by manual pushbutton. In the Retrig mode, the display follows input data until a rising or falling edge (selected on the front panel) arrives at the TRIG input connector. The display then latches, and the next selected edge updates the display each time it appears at the input.

In the Latch mode, the display follows input data but ignores the TRIG input. After an ARM button is activated, the next trigger input latches the display, but subsequent inputs have no effect until the system is re-armed. The display follows input data directly in the Run mode, and manual triggering is performed by pushbutton in the Man mode.

Gene Heftman
New York Field Bureau Editor

Each logic indicator provides high input impedance—0.5 MΩ, 0.6 pF at the connector—and high speed. The maximum input frequency is 5 MHz and the minimum input pulse width is 100 ns.

Three methods for selecting logic-level thresholds are provided. For standard TTL, a fixed 2.2-V dc level is built in. Monitoring terminals on the front panel control thresholds between −5 and +10 V dc, and those that are power-supply dependent, equal to 70% of the V_{cc} of the circuit under test.

Forty easy-clips connect the LM-3 to the circuit under test. The clips are assembled in a 40-conductor ribbon cable that plugs into a keyed, polarized, locking-type front-panel connector. TRIG inputs enter the instrument through a front-panel BNC connector. A front-panel Slope switch selects the edge—rising or falling—on which triggering occurs. The Trig threshold level control setting is identical to the selected threshold at the input channels.

Applications for the LM-3 range from microprocessor tests to systems tests. For example, the instrument can monitor all 40 pins (or any combination) on a μP package. At the board level, the 40 pins can be split up to compare 20 signal points on a properly operating board against the same points on a failed board. In system tests, selected strobes at the trigger input freeze the pattern of circuit operation on the display LEDs.

In process control applications, the LM-3 monitors 40 digital signal lines or 40 alarm points, at one time. Its input circuitry allows it to work directly with solid-state logic levels and interface with most types of switching transducers. Even difficult system applications—monitoring up to 40 variable transducers—are no problem for the instrument because of the analog characteristics of its input comparators.

For training or educational programs, the 40-LED display allows students to understand the concept of changing digital states within systems. In the lab, the instrument can be operated either conventionally, or as 40 separate, remote logic indicators.

All but five of the front panel LEDs are red; green lamps are at test positions 8, 16, 24, 32 and 40. Discrete red LEDs also serve as the power-on light and the latch-ready indicator.

Input power requirements are 105 to 135 V ac, 57 to 63 Hz. A 215 to 250-V-ac version, 50 to 60 Hz, is also available. The instrument measures 3 × 10 × 7 in. It operates over an ambient temperature range of 0 to 40 C. Included in the selling price are the 40-conductor test cable with easy clips and a V_{cc} sense cable with a banana jack to alligator-clip terminations. Available as an option is an 18-in. V_{cc} sense-input cable, terminated with polarized, dual banana plugs at one end, and red and black vinyl alligator clips at the other.

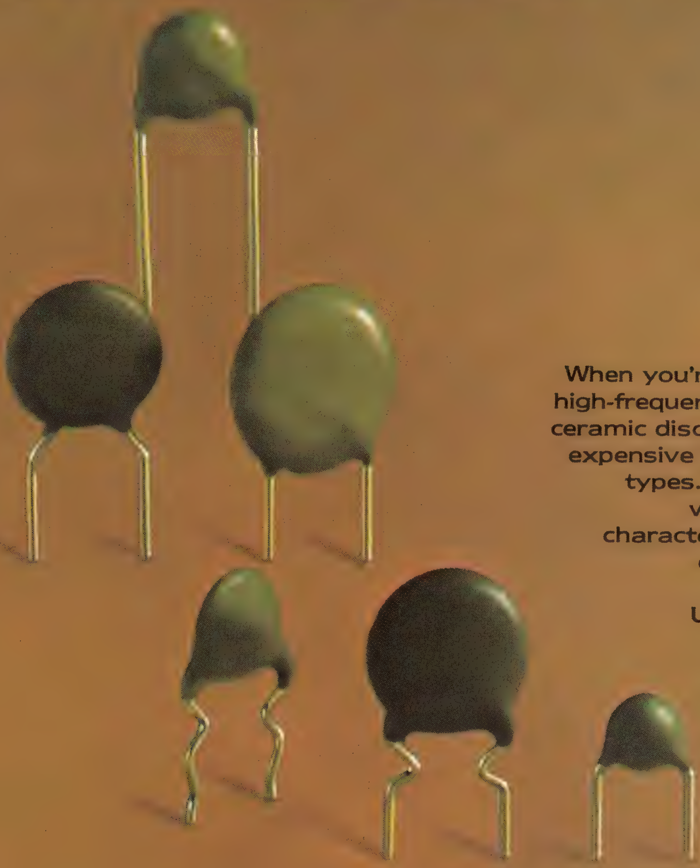
CIRCLE NO. 301

The foremost solution
to monolithic capacitor performance with disc economy...

Ultra-Kap® Ceramic Disc Capacitors

from

CENTRALAB



When you're selecting capacitors for low-voltage, high-frequency applications, Centralab's Ultra-Kap ceramic disc is the economical alternative to more expensive film, tantalum and multi-layer ceramic types. Look at the specs and you'll find that when you can't afford the performance characteristics of an X7R monolithic, but your circuit demands better stability than a hi-K dielectric ceramic disc, the Ultra-Kap is the answer. It will provide the stability and ceramic reliability you need at a reasonable price.

With Ultra-Kap, you get a non-polarized, temperature-stable capacitor with excellent high frequency characteristics and a small package size. You get the kind of ceramic reliability that's been proven in many types of severe environmental and other demanding applications.

They're available in a wide variety of lead configurations and are offered with your choice of tape and reel packaging for automatic insertion. Standard sizes and values are stocked for off-the-shelf delivery by over 200 Centralab Industrial Distributors.

Discover the foremost source for your ceramic capacitor requirements. Call your Centralab Representative, Industrial Distributor or write Centralab Electronics, Division Globe-Union Inc., 5757 North Green Bay Avenue, P.O. Box 591, Milwaukee, Wisconsin 53201.

CIRCLE NUMBER 66

CENTRALAB
REPRESENTATIVES

ARGENTINA
Buenos Aires
ELECTROIMPEX S.A.
☎ 826-6539

AUSTRALIA
Balmain
AMTRON TYREE
HOLDING PTY. LTD.
☎ 82-0701

BRAZIL
Sao Paulo
CENTRALAB DO BRAZIL
☎ 548-5569

COLOMBIA
Pereira
ELECTRONICA
ANDINA, LTDA.
☎ 36-930

DENMARK
Herlev
A/S NORDISK
ELEKTRONIK
☎ (02) 842000

FINLAND
Helsinki
NORES & CO. OY
☎ 13-360

FRANCE
Paris
RADIO TELEVISION
FRANCAISE
☎ 747-11-01

GREECE
Athens
THANOS HOUDZOUMIS
☎ 32.38.536

HONG KONG
Kowloon
CENTRALAB HONG
KONG LTD.
☎ 3-753131-4

ISRAEL
Tel-Aviv
LANDSEAS
(ISRAEL) LTD.
☎ 247291-4

ITALY
Milano
COMPREL S.R.L.
☎ (02) 61.20.641

JAPAN
Tokyo
SEISHIN TRADING
CO. LTD.
☎ (03) 503-2871
Tokyo
TECHNITRON SUPPLY
CORPORATION
☎ (03) 726-6188
Tokyo
OHMIYA CHEMICAL
CO. LTD.
☎ (03) 270-8951

MEXICO
Mexico City
CIA GENERAL
DE ELECTRONICA, S.A.
☎ 561-3211

NETHERLANDS
Zaandam
BODAMER
INTERNATIONAL B.V.
☎ 351521

NEW ZEALAND
Auckland
CHANNEL MASTER
(N.Z.) LTD.
☎ 599-003

NORWAY
Oslo
OLA TANDBERG
ELEKTRO A/S
☎ 19 70 30

PHILIPPINES
Manila
F. H. STEVENS & CO.
(INCORPORATED)
☎ 48-79-96

PORTUGAL
Lisbon
SOCIEDAD COMERCIAL
RUALDO L.D.A.
☎ PPC 36 37 25

REPUBLIC OF PANAMA
Panama
GUILLERMO A. VILORIA
☎ 22-3813

SPAIN
Barcelona
CUARZO
RADIOELECTRICO
ESPANOL, S.A. (CRESA)
☎ 230-5507

SWEDEN
Farsta
TRACO AB
☎ 08-93 09 60

SWITZERLAND
Zurich
ROTRONIC AG
☎ 01-52 32 11

TAIWAN
Chung Li
CENTRALAB
TAIWAN LTD.
☎ 034-422174

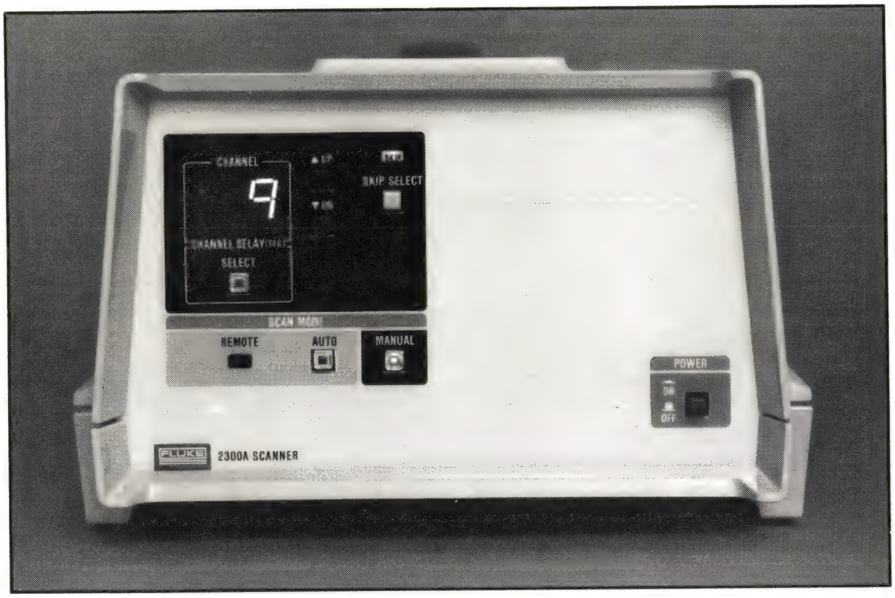
UNITED KINGDOM
London
G. E. ELECTRONICS
(LONDON) LTD.
☎ 01-727 0711/3

VENEZUELA
Valencia
PRODUCTOS
ELECTRONICOS
SURAMERICANOS, C.A.
☎ (041) 82666

WEST GERMANY
Grunwald
BODAMER GMBH
☎ 0 89/64 10 49

YUGOSLAVIA
Brussels
BELRAM S.A.
☎ 027 343332

New temperature scanner is accurate, inexpensive



John Fluke Manufacturing Co., Inc., P.O. Box 43210, Mountlake Terrace, WA 98043. Bob O'Brian (800) 426-0361. P&A: See text.

Fluke's 2300A temperature scanner with up to 20 channels of input capability, now makes it possible to build a system that offers 20% to 50% better accuracy than an equivalent general-purpose data-logger system configured for temperature scanning—at lower cost.

Although more accurate than a data logger, the scanner is slower. With a logger, 15 channels can be read every second, compared with a rate of one channel every 2 seconds for the new temperature scanner.

A basic temperature scanning system is made up of the 2300 scanner mainframe equipped with an optional 10-channel thermocouple or RTD card and a Fluke 2180A/2190A digital thermometer. For a hard-copy record, a printer can be added; the total system price is under $3000.

In the standard configuration, up to 20 input channels can be accommodated using two optional thermocouple or RTD scanner cards added to the scanner mainframe. With the optional 2301A extender chassis, the unit can accept up to 100 channels of input. A wide variety of thermocouples can be used. Larger inputs, or applications where other parameters besides temperature are measured, require the added capability of a data logger.

The scanner can be operated automatically or manually. In addition, the instrument can be programmed to skip channels and scan fast forward or reverse. The instrument can delay the time interval between scanner relay contact closure and its trigger signal, initiating measurement instrument reading. The delay can be programmed from 0.0 to 9.9s.

With the optional RTD scanner card, RTD types accepted include the 100-Ω 385 Pt (DIN), the 100-Ω 390 Pt, the 392 Pt, the 100-Ω Ni (DIN), the 10-Ω Cu, or the 0 to 1000-Ω resistance type.

Direct connection to a computer system occurs via a standard RS-232C interface or 20-mA current loop on the scanner's rear panel. Interface with other Fluke instruments can occur over the company's own portable test instrument (PTI) bus. To put the scanner on the IEEE-488 bus requires a Fluke 1120A Translator.

Price for the scanner mainframe with optional 10-channel scanner card is $1120; delivery is 30 days after order.

CIRCLE NO. 310

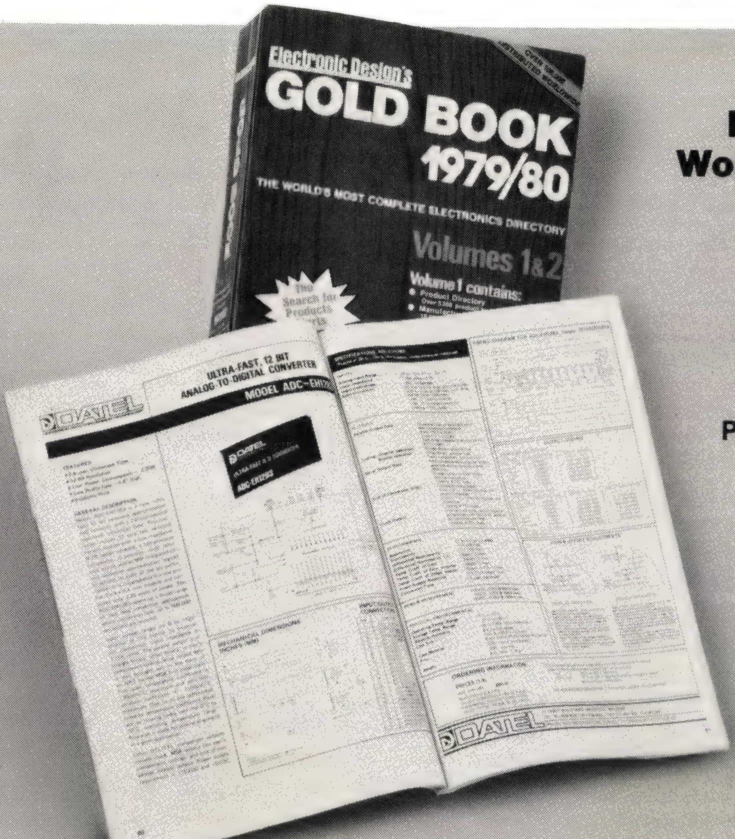
DATEL-INTERSIL

SineTrac A/D-D/A Boards for your Microcomputer

CHOOSE SINETRAC A/D-D/A BOARDS FOR:

INTEL SBC-80
DEC LSI-11®
DEC PDP-11®
MOTOROLA 6800 EXORCISER
DATA GENERAL NOVA,
ECLIPSE
MP-100/200

Make your Computer plug into the Analog World!


Electronic Design's
GOLD BOOK
1979/80
THE WORLD'S MOST COMPLETE ELECTRONICS DIRECTORY
Volumes 1 & 2
Volume 1 contains:
DATEL
ULTRA-FAST, 12 BIT ANALOG-TO-DIGITAL CONVERTER
MODEL ADC-EH12
DATEL

Datel-Intersil and Gold Book. Working Together to Make Your Job Easier!

Together again for the 3rd year — Datel-Intersil and Electronic Design's Gold Book. Volume III of the 1979-80 Edition of Gold Book is the Datel-Intersil Engineering Product Handbook which contains complete specifications, product descriptions and application information.

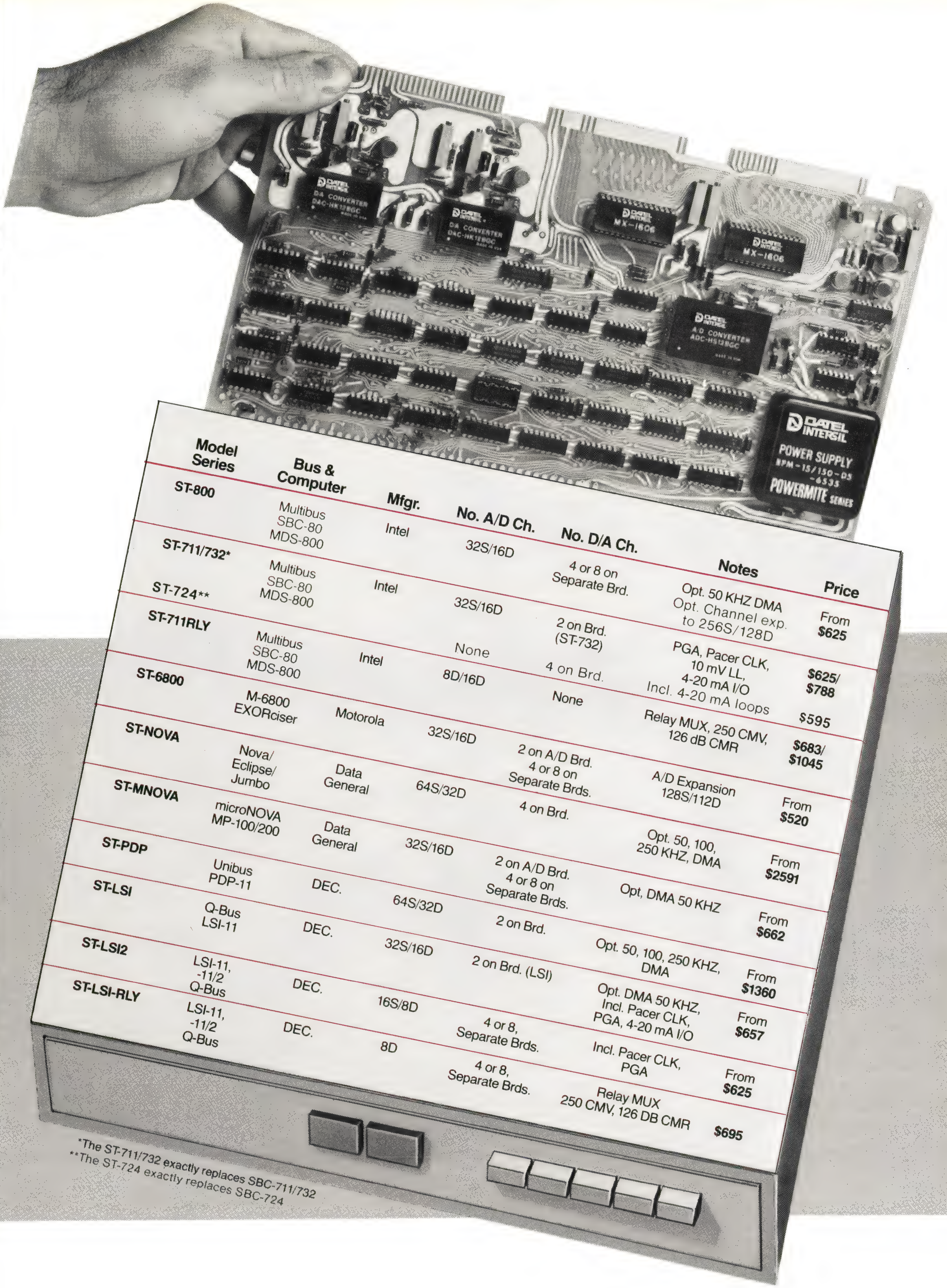
So don't be delayed on your projects while waiting for product literature to arrive. Check the spec's in Gold Book today.

Electronic Design's, Gold Book the world's most complete electronics directory

DATEL INTERSIL

11 CABOT BOULEVARD, MANSFIELD, MA 02048 / TEL. (617)339-9341 / TWX 710-346-1953 / TLX 951340
Santa Ana, (714)835-2751, (L.A.) (213)933-7256 • Sunnyvale, CA (408)733-2424 • Gaithersburg, MD (301)840-9490
• Houston, (713)781-8886 • Dallas, TX (214)241-0651 OVERSEAS: DATEL (UK) LTD—TEL: ANDOVER (0264)51055
• DATEL SYSTEMS SARL 602-57-11 • DATELEK SYSTEMS GmbH (089)77-60-95 • DATEL KK Tokyo 793-1031

DEC and PDP are trademarks of Digital Equipment Corporation

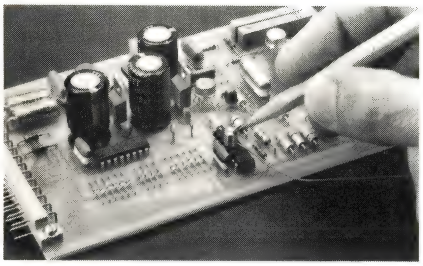

DATEL INTERSIL
D/A CONVERTER DAC-HK12BGC
MX-1606
A/D CONVERTER ADC-HS12BGC
DATEL INTERSIL POWER SUPPLY BPM-15/150-D5 -6535 POWERMITE SERIES

Model Series	Bus & Computer	Mfgr.	No. A/D Ch.	No. D/A Ch.	Notes	Price
ST-800	Multibus SBC-80 MDS-800	Intel	32S/16D	4 or 8 on Separate Brd.	Opt. 50 KHZ DMA Opt. Channel exp. to 256S/128D	**From $625**
ST-711/732*	Multibus SBC-80 MDS-800	Intel	32S/16D	2 on Brd. (ST-732)	PGA, Pacer CLK, 10 mV LL, 4-20 mA I/O	**$625/ $788**
ST-724**			None	4 on Brd.	Incl. 4-20 mA loops	**$595**
ST-711RLY	Multibus SBC-80 MDS-800	Intel	8D/16D	None	Relay MUX, 250 CMV, 126 dB CMR	**$683/ $1045**
ST-6800	M-6800 EXORciser	Motorola	32S/16D	2 on A/D Brd. 4 or 8 on Separate Brds.	A/D Expansion 128S/112D	**From $520**
ST-NOVA	Nova/ Eclipse/ Jumbo	Data General	64S/32D	4 on Brd.	Opt. 50, 100, 250 KHZ, DMA	**From $2591**
ST-MNOVA	microNOVA MP-100/200	Data General	32S/16D	2 on A/D Brd. 4 or 8 on Separate Brds.	Opt, DMA 50 KHZ	**From $662**
ST-PDP	Unibus PDP-11	DEC.	64S/32D	2 on Brd.	Opt. 50, 100, 250 KHZ, DMA	**From $1360**
ST-LSI	Q-Bus LSI-11	DEC.	32S/16D	2 on Brd. (LSI)	Opt. DMA 50 KHZ, Incl. Pacer CLK, PGA, 4-20 mA I/O	**From $657**
ST-LSI2	LSI-11, -11/2 Q-Bus	DEC.	16S/8D	4 or 8, Separate Brds.	Incl. Pacer CLK, PGA	**From $625**
ST-LSI-RLY	LSI-11, -11/2 Q-Bus	DEC.	8D	4 or 8, Separate Brds.	Relay MUX 250 CMV, 126 DB CMR	**$695**

*The ST-711/732 exactly replaces SBC-711/732
**The ST-724 exactly replaces SBC-724

CIRCLE NUMBER 67

Mini probe monitors component vibration



Kistler Instrument, 75 John Glenn Dr., Amherst, NY 14120. (716) 691-5100.

A miniature accelerometer, Model 811A, monitors PC-board component shock and vibration. The device measures 1/5-in. across and weighs less than 0.5 g. Flat frequency response extends to 25 kHz. Sensitivity is 7 mV/g. The piezo-electric device includes its own electronics. Low impedance output eliminates need for special low-noise cables. The device uses adhesive mounting techniques. A mounting stud adaptor provides electrical ground isolation. Temperature range is −195 to 135 C.

CIRCLE NO. 320

Megohmeter checks insulation resistance

Associated Research, 8221 N. Kimball Ave., Skokie, IL 60076. (312) 647-7850.

"Meg-Chek" Model 2201, a megohmmeter, measures insulation resistance for early diagnosis of equipment failure. A sharp drop in insulation resistance can indicate impending failure of wiring and motor windings. The instrument measures megohms, ohms and ac/dc volts without changing lead connections. Two 12-ft long test leads are supplied with a resistance card set, an instruction manual and a self-contained carrying case.

CIRCLE NO. 321

Instrument measures optical characteristics

Photodyne, 5356 Sterling Center Dr., Westlake Village, CA 91361. (213) 889-8770. P&A: See text.

Model 99XL, a precision densitometer/reflectometer, uses interchangeable fiber optic head assemblies for optical measurement ease. Fiber optic cable interconnects the instrument with any of four heads for transmission or reflection measurements. The unit is autoranging and autozeroing over eight decades. Repeatability is 0.005 density units; accuracy, 0.01 density units. A 3-1/2 digit, 1/2-in. high LCD display is backlighted for darkroom use. A 34-pin edge connector brings out digital and analog signals for driving external recorders or interface to minicomputers. A dual-mode feature uses two detectors to record transmission or reflection density difference between two channels. Model 99XL costs $895. Measurement heads range from $45 to $265.

CIRCLE NO. 322

HV pulse driver operates at up to 100-kHz rep rate

Rofin, Echo Bridge Office Park, 381 Elliot St., Newton Upper Falls, MA 02164. (617) 527-4884. $5000 to $7000.

A high-voltage, general-purpose pulse driver, Model 7540, provides up to 5-kV outputs, at repetition rates variable up to 100 kHz. Balanced ±2.5 kV outputs are available. There is no duty-cycle limitation. Pulse width can be varied from 0 to 10 μs. The unit will drive capacitive loads of up to 50 pF. Applications include modulator switching, non-destructive testing and high-voltage control. The units mount in a 19-in. rack.

CIRCLE NO. 323

INTERNATIONAL REPRESENTATIVES
FOR GRAYHILL
SWITCHES AND KEYBOARDS

AUSTRALIA—Acme Engineering Co., (Pty) Ltd.
2-18 Canterbury Road
Kilsyth, Victoria 3137
Tel: (03) 729-6211
Telex: 35786 WILACM

BELGIUM/LUXEMBOURG—
Rodelco SA/NV Electronics
Avenue H Hooverlaan, 32
1200 Brussels
Tel: (02) 735·41·37
Telex: 61415

CANADA—A. C. Simmonds & Sons Ltd.
975 Dillingham Road
Pickering, Ontario LIW 3B2
Tel: (416) 839-8041
Telex: 06-981383 (SIMMONDS PICK)
Also Calgary • Montreal • Ottawa • Burnaby

DENMARK—E. V. Johanssen Elektronik A-S
15, Titangade
DK-2200 Copenhagen N
Tel: (01) 83 90 22
Telex: 16522 (EVICAS DK)

FRANCE—Radio Television Francaise
73, Avenue Charles-De-Gaulle
92200 Neuilly-Sur-Seine
Tel: (01) 747-11-01
Telex: 611985

GERMANY—Data Modul GmbH
Landsbergerstr. 289
D-8000 Munchen 21
Tel: (089) 58 30 66
Telex: 5213118 (DAMO D)

ISRAEL—Rapac Electronics Ltd.
P.O. Box 18053
Tel-Aviv 61180
Tel: (03) 45 42 46
Telex: 922-33528 (RAPAC IL)

ITALY—Microelit s.r.l.
Via P. Uccello, 8
20148 Milano
Tel: (02) 46 90 444
Telex: 334284 MICROIT

JAPAN—Jepico Corp.
Sagmi Bldg.
Shinjuku 4-2-21
Shinjuku-ku, Tokyo
Tel: 03 (354) 4661
Telex: 02 323167 (JEPICO J)

NETHERLANDS—Rodelco BV Electronics
Verrijn Stuartlaan, 29
2280 AG Rijswijk
Tel: (070) 995750
Telex: 32506

NEW ZEALAND—
S. D. Mandeno Electronic Equipment Co.
10 Woodhall Road
Auckland 3,
Tel: (09) 600-008

NORWAY—Hans H. Schive A/S
Gustav Vigelandsvei, 5
Oslo 2
Tel: (02) 55 76 92
Telex: 19124 (SKIVE N)

SOUTH AFRICA—L'Electron (Pty) Ltd.
P.O. Box 10544
2000 Johannesburg
Tel: 408057
Telex: 8-2333 S.A.

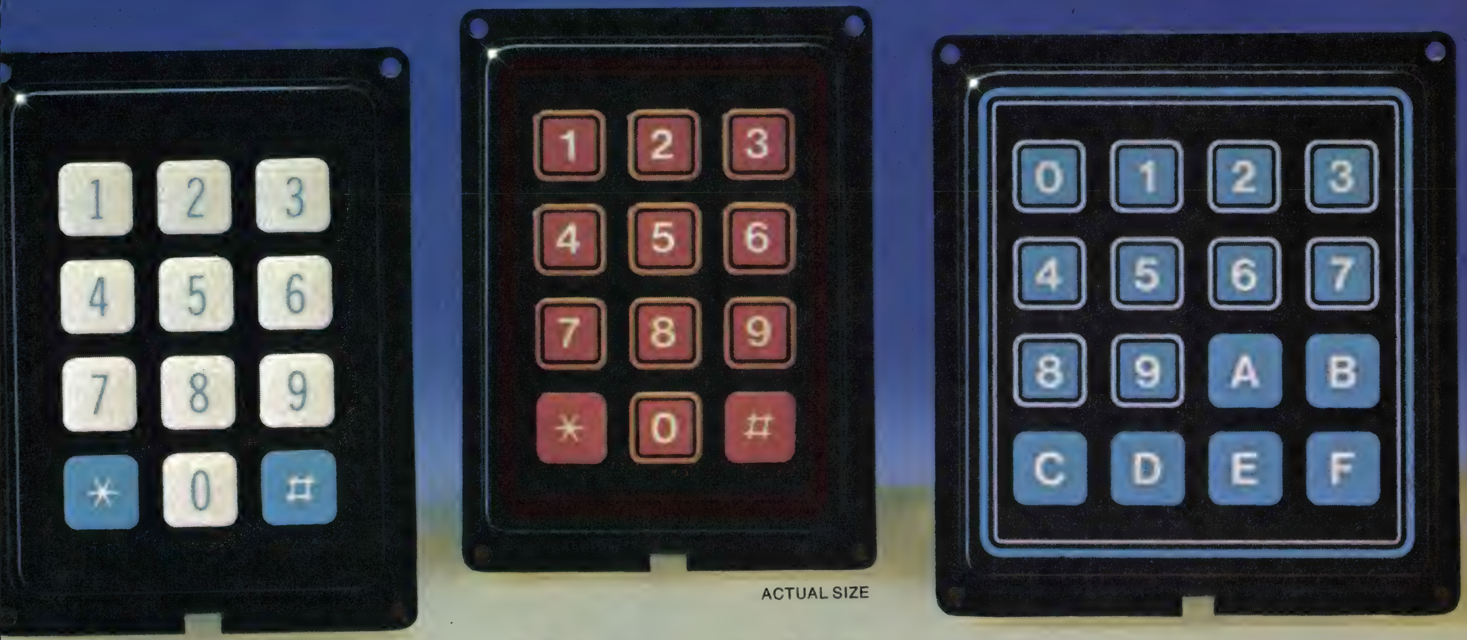
SPAIN—Unitronics SA
Torre De Madrid
Madrid, 13
Tel: (01) 242 52 04
Telex: 22596 (UTRON E)

SWEDEN—Bo Palmblad AB
Hornsgatan, 58
S-10462 Stockholm 17
Tel: (08) 246160
Telex: 10696 (ZEDKEY S)

SWITZERLAND—Walter Blum Ltd.
Honggerstrasse, 115
CH-8037 Zurich
Tel: (01) 42 23 42
Telex: 53294 (WBLCO CH)

UNITED KINGDOM—Highland Electronics, Ltd.
8 Old Steine
Brighton BN1 1EJ
East Sussex, England
Tel: (0273) 693688
Telex: 87616 (HIELEC G)
Hillend Industrial Estate
Dunfermline, Fife KY11 5JT, Scotland
Tel: (0383) 822911
Telex: 72672 HIELEC DUNFRMLN

Grayhill's New
SEALED KEYBOARDS
SPILLPROOF! TACTILE FEEDBACK! LONG LIFE!



Here . . . at last . . .
a sealed keyboard that lets you hear and feel the actuation!

These new Grayhill Series 88 sealed keyboards are available now in 3x4 and 4x4 button configurations with one-half inch button centers. The graphic overlay, which seals the keyboard surface and the contact system, resists the vast majority of common contaminants. Thus, these keyboards can be used out-doors as well as in applications that require a washable front surface. Graphic overlays come in a variety of standard colors and formats; custom nameplates can also be provided.

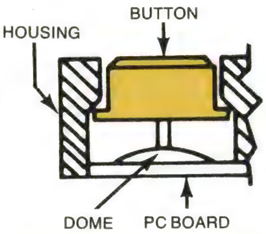
Grayhill Series 88 keyboards are flange mounted. Special gaskets seal the flange surface for either front panel or sub-panel mounting.

The Grayhill Series 88 electrical characteristics have been designed to be compatible with logic circuitry and are rated at 3,000,000 operations per button. The Series 88 is offered with matrix, 2 out of 7, 2 out of 8, or single pole/common bus circuitry. The snap dome contact system provides positive audible and tactile feedback to the operator.

Engineering data and prices are yours for the asking in Bulletin No. 297.

Spill-proof,
contamination-proof

Snap-dome contacts give
positive operator feedback



One of five standard
3x4 legends

One of four standard
4x4 legends

Custom graphic overlays to
your exact specifications

Grayhill INC

. . . the Difference Between Excellent and Adequate
561 Hillgrove Avenue, LaGrange, IL 60525
Phone (312) 354-1040

CIRCLE NUMBER 68

Meter/integrator monitors solar insolation

Li-Cor, 4421 Superior St., Lincoln, NE 68504. (402) 467-3576. P&A: See text.

A microprocessor-controlled meter/integrator, LI-1776, measures and records solar insolation. Instantaneous or integrated measurements of solar energy can be taken, with direct readout in appropriate units of watts or BTUs. Integrated data, such as daily totals, for over 100 periods are automatically stored in memory for later recall. An output is available for strip-chart recorders, dataloggers and other millivolt recorders. With an optional input module, the instrument can be used with thermopile pyranometers. An external power supply provides long-term, unattended monitoring. Battery backup protects data. The monitor costs $635; the LI-200SC pyranometer, $140; a LI-200SC mounting fixture, $40. The 1776-01 millivolt input module, for use with other pyranometers, costs $100. The solar monitor will be available in April.

CIRCLE NO. 324

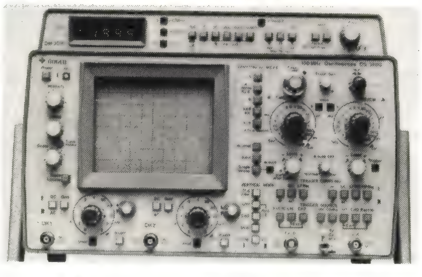
Auto level set speeds distortion analysis

Krohn-Hite, Avon Industrial Park, 255 Bodwell St., Avon, MA 02322. (617) 580-1660. $1600; 8 to 9 wks.

Totally automatic level setting over a 100 mV to 13-V rms range eliminates time-consuming adjustments and speeds distortion analysis with the Model 6801. The instrument measures total harmonic distortion down to 0.003%, typically with 0.001% resolution. As an ac voltmeter, the 6801 covers a 10 Hz to 110-kHz range and will measure from 10 mV to 13 V rms. A distortion output is provided for visual inspection or spectral analysis of an input signal after the fundamental has been filtered out.

CIRCLE NO. 325

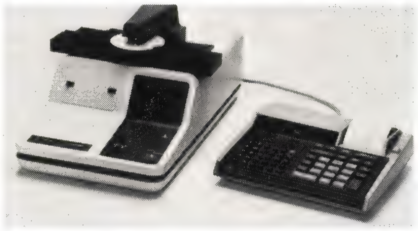
100-MHz oscilloscope tacks on DMM option



Gould Instruments, 3631 Perkins Ave., Cleveland, OH 44114. (216) 361-3315. $2699; $3299 (with DMM); 8 to 9 wks.

A 100-MHz, dual-trace oscilloscope, OS3600, uses a digital multimeter add-on for increased measurement versatility. The 3-1/2 digit DMM, Model DM3010, is offered as a factory installed unit or a retrofit. Used with the scope, it measures signal amplitude, time and frequency. It operates independently to measure dc voltage, dc current and resistance. The scope has a vertical sensitivity of 5 mV/cm over the full bandwidth and 2 mV/cm up to more than 85 MHz. Display modes include CH1 or CH2 alone, CH1 and CH2 alternate or chopped, CH1 and CH2 added algebraically and X-Y. A trigger view facility displays up to three traces: CH1, CH2 and the internal or external signal triggering the main timebase. The 8 × 10 cm CRT uses a parallax-free internal illuminated graticule. CIRCLE NO. 326

Measure wafer thickness with no-contact tester



Tencor Instruments, 2426 Charleston Rd., Mountain View, CA 94043. (415) 969-6767.

M-Gage, a non-contact metal thickness gauge, calculates and displays the thickness of metal films. Infrared sensors monitor a wafer's progress as it automatically advances along an indexed carriage. Measurements are programmed for 1, 5 or 9-point patterns, allowing monitoring of coating thickness uniformity. On multiple point measurements, mean thickness and standard deviation can be printed on a Hewlett-Packard calculator attached to the system.

CIRCLE NO. 327

Berg Electronics products are available through these leading distributors:

ARIZONA
Phoneix
Weatherford
602-272-7144
CALIFORNIA
Anaheim
Weatherford
714-634-9600

Belmont
LoDan
415-592-4600

Glendale
Weatherford
213-849-3451

Inglewood
Force Electronics
213-776-1324

Palo Alto
Weatherford
415-493-5373

San Diego
Weatherford
714-278-7400
COLORADO
Englewood
Weatherford
303-770-9762
CONNECTICUT
Norwalk
Harvey
203-853-1515
FLORIDA
Orlando
Hammond
305-849-6060
ILLINOIS
Arlington Heights
LoDan
312-398-5311
INDIANA
Fort Wayne
Fort Wayne Electronics
219-423-3422

Indianapolis
Graham
317-634-8202
KANSAS
Kansas City
Tennant
913-287-2100
MARYLAND
Baltimore
Resco/Baltimore
301-823-0070

Beltsville
Resco/Washington
301-937-9100
MASSACHUSETTS
Lexington
Harvey
617-861-9200

MINNESOTA
Minneapolis
Aero Space
Computer Supplies
612-884-4725
NEW JERSEY
Pinebrook
Harvey
201-227-1262
NEW YORK
Binghamton
Harvey
607-748-8211

Commack
Conco Electronics
516-543-8300

W. Henrietta
Harvey
716-334-5920

Woodbury
Harvey
516-921-8700
NORTH CAROLINA
Greensboro
Hammond
919-275-6391
OHIO
Cincinnati
Graham
513-772-1661

Cleveland
CAM/Ohio
216-461-4700
PENNSYLVANIA
Philadelphia
Almo
215-698-4000

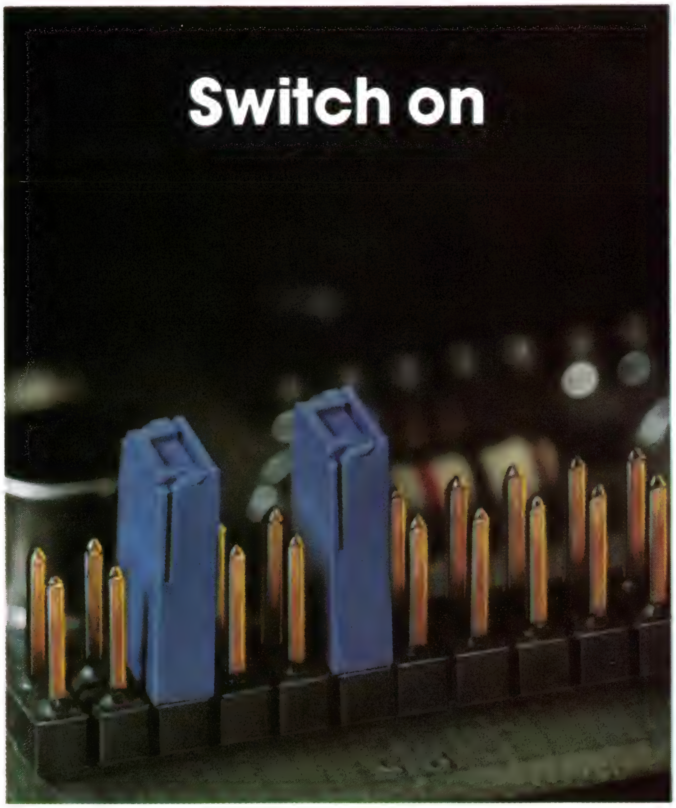
Pittsburgh
CAM/RPC
412-782-3770
SOUTH CAROLINA
Greenville
Hammond
803-233-4121
TEXAS
Austin
CSI
512-837-8922

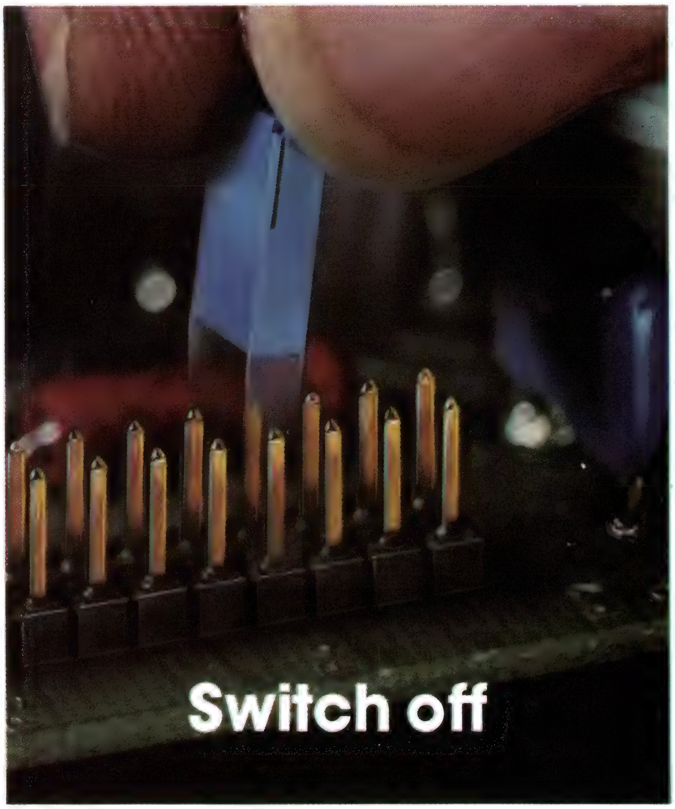
Dallas
CSI
214-357-6511

Houston
CSI
713-771-7237
WASHINGTON
Seattle
Weatherford
206-575-1340

DU PONT
REG U.S. PAT & TM OFF

DIP switches can deprogram. Berg's Mini-Jump™ can't. Our design guarantees it.



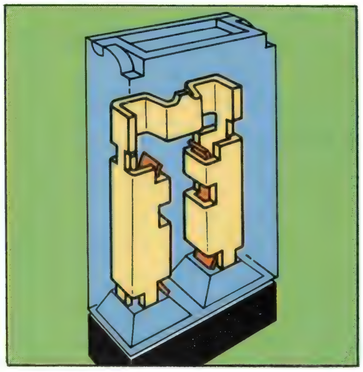


Far more reliability. Far less field service. Accidents, vibration — anytime you'd expect a DIP switch to fail, you can count on Mini-Jump* to stay programmed. Careless fingers can't deprogram it because there's no switch to hit. Only a deliberate action can change the circuit.

The interior spring of the "Mini-Jump" maintains a high normal contact force for reliability during vibration — even severe vibration. And, because you install the "Mini-Jump" after soldering, you avoid contamination which can lead to corrosion.

Permits higher density packaging. The "Mini-Jump" is available in single position, stackable on 0.100", 0.125", 0.150" and 0.200" centers. Also in two positions on 0.100" centers and three and five positions on 0.150" centers.

Write for literature. The Du Pont Company, Berg Electronics Division, New Cumberland, PA 17070. Telephone (717) 938-6711.



Inside the "Mini-Jump", dual metal PV† contacts provide excellent electrical and mechanical performance.

*Du Pont trademark for its .025" disconnect jumper.
†Du Pont trademark for its .025" dual metal female disconnect.

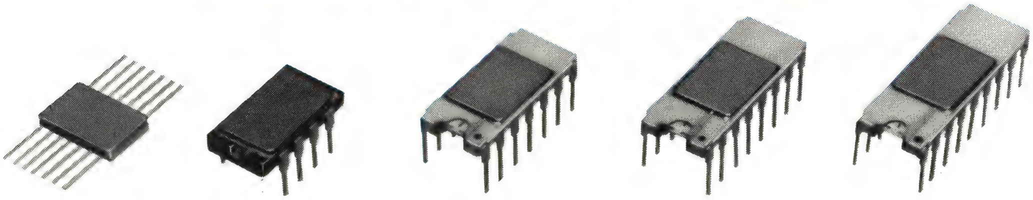
Berg Electronics

DU PONT
REG U.S. PAT & TM OFF

CIRCLE NUMBER 69

UPDATE:

POWER INTERFACE ICs TO MIL-STD-883



Take the shortcut: The quickest and easiest route to obtaining MIL-Spec ICs can be to check Sprague first. Shown below is a brief listing of recently-developed Sprague products and applicable engineering bulletins.

For the engineering bulletins of interest to you, write to: Technical Literature Service, Sprague Electric Company, 347 Marshall St., North Adams, Mass. 01247.

For application engineering assistance, write or call Walter Sullivan or Paul Emerald, Sprague Electric Company, Semiconductor Division, 115 Northeast Cutoff, Worcester, Mass. 01606. Telephone 617/853-5000.

For the name of your nearest Sprague Semiconductor Distributor, write or call Sprague Products Co. Division, North Adams, Mass. 01247. Tel. 413/664-4481.

Device	Series	Package	Max. Output Voltage	Output "1"	Engineering Bulletin
Quad Power Drivers	UHC- & UHD-400, 401-1,500	14-pin DIP or Flat-Pak	40 to 100V	to 250 mA	29300.1
7-Channel Darlington Arrays	ULS-2000H	16-pin DIP	50V/95V	to 500 mA	29304.1
8-Channel Darlington Arrays	ULS-2800H	18-pin DIP	50V/95V	to 500 mA	29304.4
Quad High Current Darlingtons	ULS-2064H to 2077H	16-pin DIP	50V/80V	to 1.25 A	29305.1
Quad Peripheral Drivers	UDS-5700H	16-pin DIP	80V	to 300 mA	29306.1
Dual Peripheral Drivers	UDS-5710H	8-pin DIP	80V	to 300 mA	29307.1
Dual Peripheral Drivers	UDS-3600H	8-pin DIP	80V	to 300 mA	29308.1
8-Channel Source Drivers	ULS-2980H	18-pin DIP	50V/80V	to 350 mA	29310.1
Quad PIN Diode Power Drivers	UDS-5790/91H	16-pin DIP	120V	to 300 mA	29315.1

FOR FAST INFORMATION, CALL YOUR NEAREST SPRAGUE SALES OFFICE:

ALABAMA, Sprague Electric Co., 205/883-0520 • **ARIZONA**, Sprague Electric Co., 602/244-0154; 604/966-7233 • **CALIFORNIA**, R. D. Miner Co., 714/421-5586; Wm. J. Purdy Co., 415/347-7701; • **COLORADO**, Wm. J. Purdy Co., 303/777-1411 • **CONNECTICUT**, Sprague Electric Co., 203/261-2551; Ray Perron & Co., Inc., 203/268-9631 • **DIST. OF COLUMBIA**, Sprague Electric Co. (Govt. sales only), 202-337-7820 • **FLORIDA**, Sprague Electric Co., 305/831-3636 • **ILLINOIS**, Sprague Electric Co., 312/296-6620 • **INDIANA**, Sprague Electric Co., 317/253-4247 • **MASSACHUSETTS**, Sprague Electric Co., 617/899-9100; Sprague Electric Co., 413/664-4411 • **MICHIGAN**, Sprague Electric Co., 517/787-3934 • **MINNESOTA**, HMR, Inc., 612/831-7400 • **MISSOURI**, Sprague Electric Co., 314/781-2420 • **NEW HAMPSHIRE**, Ray Perron & Co., Inc., 603/742-2321 • **NEW JERSEY**, Sprague Electric Co., 201/696-8200; Sprague Electric Co., 609/795-2299; Trinkle Sales Inc., 609/795-4200 • **NEW MEXICO**, Wm. J. Purdy Co., 505/266-7959 • **NEW YORK**, Sprague Electric Co., 516/234-8700; 914/834-4439; Wm. Rutt, Inc., 914/834-8555; Sprague Electric Co., 315/437-7311; Paston-Hunter Co., Inc., 315/437-2843 • **NORTH CAROLINA**, Electronic Marketing Associates, 919/722-5151 • **OHIO**, Sprague Electric Co., 513/866-2170; Electronic Salesmasters, Inc., 800/362-2616 • **PENNSYLVANIA**, Sprague Electric Co., 215/467-5252; Trinkle Sales Inc., 215/922-2080 • **TEXAS**, Sprague Electric Co., 214/235-1256 • **VERMONT**, Ray Perron & Co., Inc., 617-762-8114 • **VIRGINIA**, Sprague Electric Co., 703-463-9161 • **WASHINGTON**, Sprague Electric Co., 206/632-7761 • **CANADA**, Sprague Electric of Canada, Ltd., 416/766-6123 or 613/238-2542.

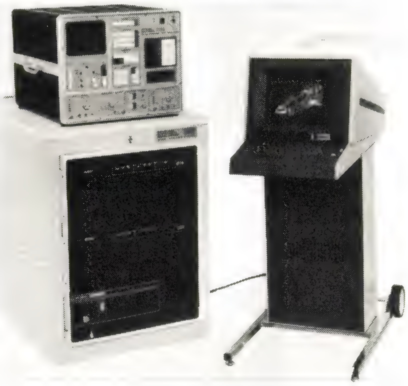
4SS-9114R2

SPRAGUE

THE MARK OF RELIABILITY

a subsidiary of **GK Technologies** Incorporated

Simple-to-use system permits modal analysis



Nicolet Scientific, 245 Livingston St., Northvale, NJ 07647. (201) 767-7100. $69,000; 13 wks.

A simple-to-operate modal analysis system, Model 6601, provides interactive, self-explanatory operation for the operator with no programming experience. The system is built around the Model 660A-2D, a dual-channel FFT analyzer. A large, bright animated display of a test object is supplied by a high-speed terminal at 5000 vectors/s. The object may be viewed at any angle in perspective. Up to four views can be simultaneously displayed and as many as 50 modes can be extracted. Floppy disks store up to 7500 transfer functions for later re-examination. Excitation of the test object can be random (source provided), swept-sine or impulse. Zoom analysis and multiple parameter extraction methods permit identification of closely-spaced modes.

CIRCLE NO. 328

Compact monitor detects combustible gases

Perkins Research and Manufacturing, 6635 Independence Ave., Canoga Park, CA 91303. (213) 887-1897.

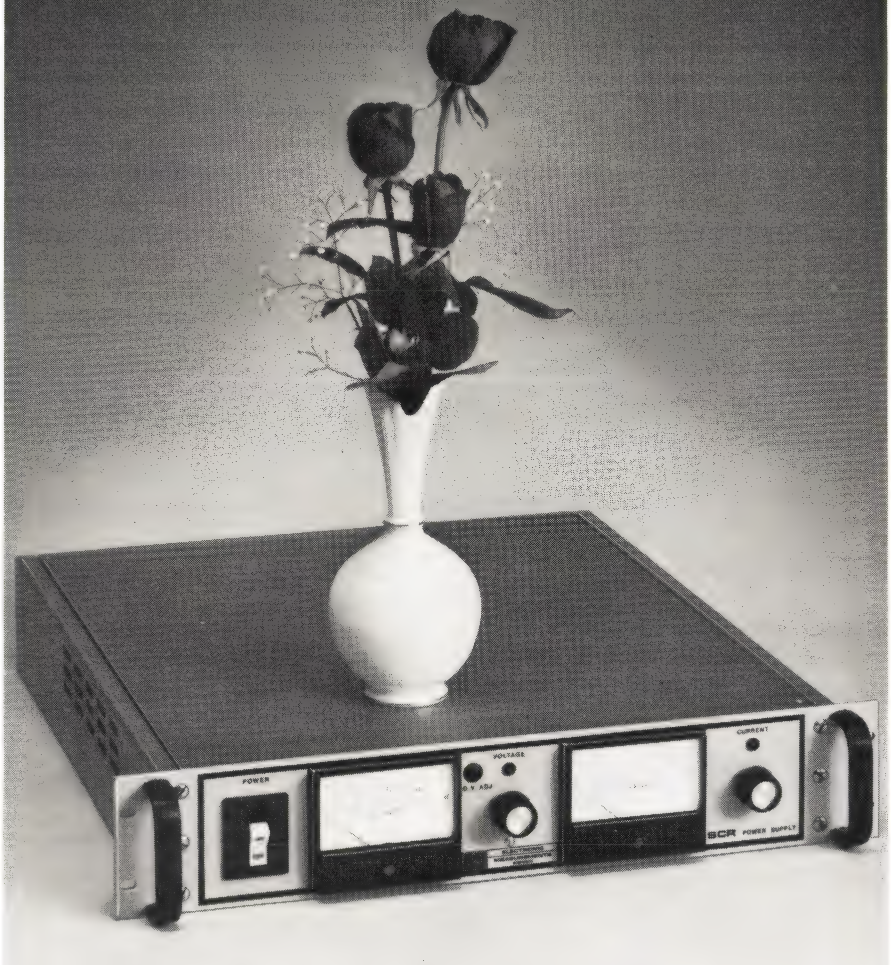
A compact combustible gas detector, Model PR122A, provides 10 continuous hours of protection on a single battery charge. The detector sounds an alarm when gas concentration reaches a preset level. The alarm is a solid-state device producing a 70-dB, steady tone. Accessories for the belt-worn unit include a battery pack and charger, a carrying case, calibrating gas and a test chamber.

CIRCLE NO. 329

quality

When we say our SCR power supplies are good, it doesn't mean that much. But when ***our customers*** say it, it means a lot. They say it by being satisfied with what they get. . . And by coming back for more.

In a word: quality. In another word: excellence.



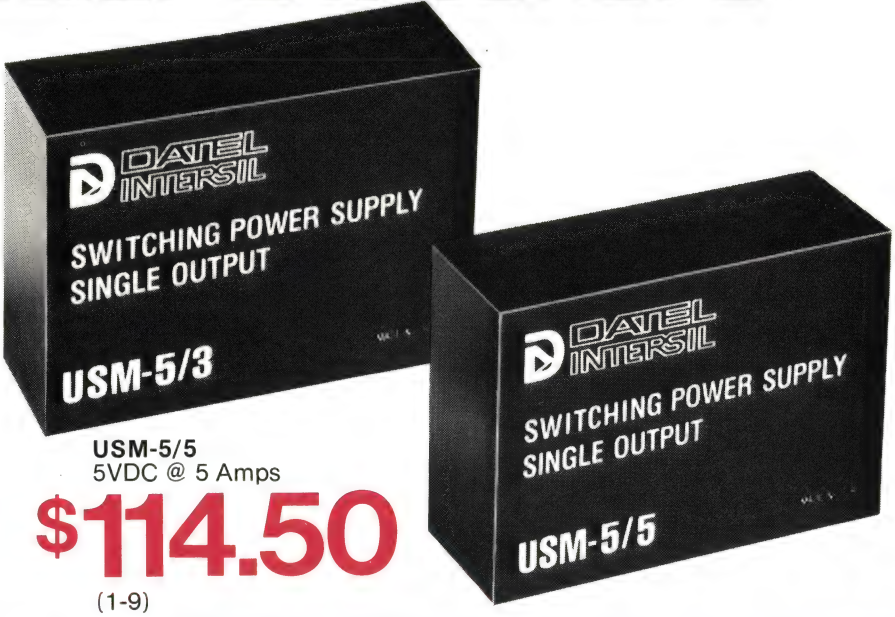
One- and three-phase rack-mounted power supplies from 500 to 10,000 watts. Call **TOLL FREE 800-631-4298*** *for complete information and prices, or write for our catalog.*
*Except in New Jersey, Hawaii & Alaska

E/M
ELECTRONIC MEASUREMENTS INC.
405 Essex Road, Neptune, NJ 07753
Phone: 201-922-9300. **TOLL FREE 800-631-4298***
Specialists in Power Conversion Equipment

CIRCLE NUMBER 71

DATEL-INTERSIL

Two High Performance Modular Switchers

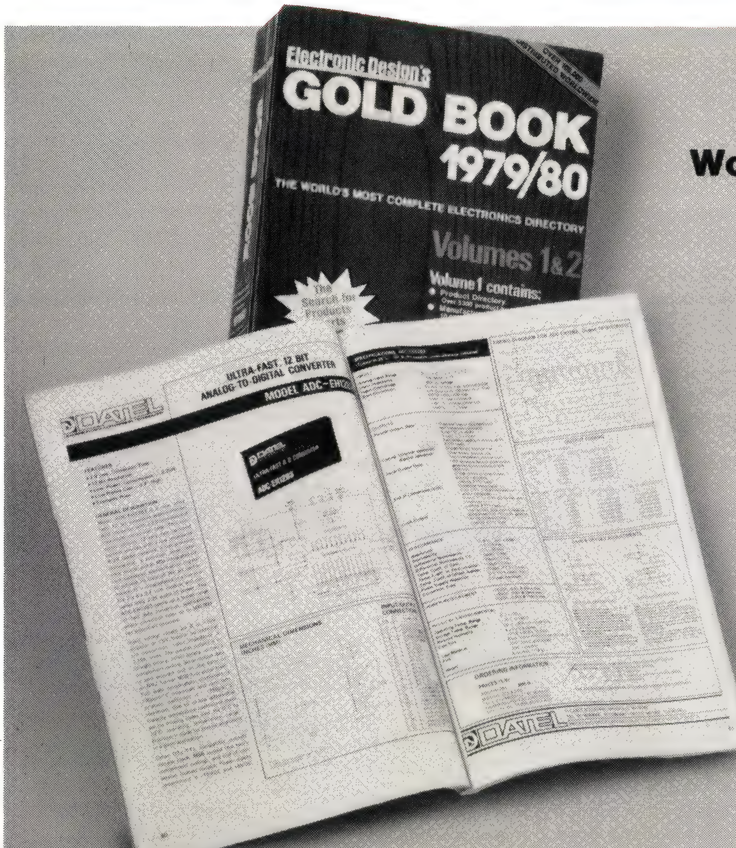


FEATURES:

- 5VDC ± 1% Output
- 80% Min. Efficiency
- 90 to 130 VAC Input
- 0.1% Load Regulation
- 50 mV P-P Max. Output Ripple
- Short Circuit & Overvoltage Protection
- Compact 3.5 x 2.5 x 1.25" Module

USM-5/3
5VDC @ 3 Amps
$98.50
(1-9)

USM-5/5
5VDC @ 5 Amps
$114.50
(1-9)


Electronic Design's
GOLD BOOK
1979/80
THE WORLD'S MOST COMPLETE ELECTRONICS DIRECTORY
Volumes 1&2
ULTRA-FAST, 12 BIT ANALOG-TO-DIGITAL CONVERTER
DATEL

Datel-Intersil and Gold Book. Working Together to Make Your Job Easier!

Together again for the 3rd year — Datel-Intersil and Electronic Designs Gold Book. Volume III of the 1979-80 Edition of Gold Book is the Datel-Intersil Engineering Product Handbook which contains complete specifications, product descriptions and application information.

So don't be delayed on your projects while waiting for product literature to arrive. Check the spec's in Gold Book today.

Electronic Designs, Gold Book the world's most complete electronics directory

DATEL INTERSIL

11 CABOT BOULEVARD, MANSFIELD, MA 02048 / TEL. (617)339-9341 / TWX 710-346-1953 / TLX 951340
Santa Ana, (714)835-2751, (L.A.) (213)933-7256 • Sunnyvale, CA (408)733-2424 • Gaithersburg, MD (301)840-9490
• Houston, (713)781-8886 • Dallas, TX (214)241-0651 OVERSEAS: DATEL (UK) LTD—TEL: ANDOVER (0264)51055
• DATEL SYSTEMS SARL 602-57-11 • DATELEK SYSTEMS GmbH (089)77-60-95 • DATEL KK Tokyo 793-1031

CIRCLE NUMBER 70

Delayed sweep scope evaluates digital info

B&K-Precision, 6460 W. Cortland St., Chicago, IL 60635. (312) 889-9087. $1340; stock.

Delay-sweep capability of the Model 1530 oscilloscope aids the evaluation of digital pulse trains and other complex waveforms. The 30-MHz scope offers five ranges of time-base delay from 1 μs to 100 ms. Vertical input sensitivity is 2 mV/div. Using delayed sweep, a complex digital pulse train can be expanded and individual pulse signals examined. Waveforms with repetition rates to 25 kHz can be expanded by as much as 1000 times. A variable hold-off feature permits more accurate display of digital information by assuring that a sweep is triggered by the first pulse of a multipulse signal. Chop or alternate modes of dual-trace display can be selected at sweep times of 1 ms/div. and slower. Alternate is automatically selected at higher sweep speeds. Other features include front-panel X-Y operation, differential measurement capability and algebraic addition and subtraction of two vertical input signals.

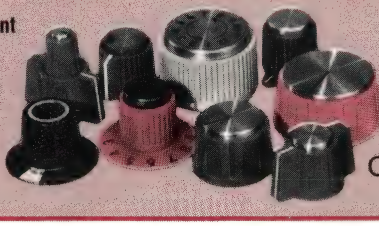
CIRCLE NO. 330

Controller directs GPIB test instruments

Systron-Donner, 935 Detroit Ave., Concord, CA 94518. (415) 676-5000. P&A: See text.

An instrumentation controller, Model 3250, directs the operation of IEEE-488 (GPIB) compatible test instruments, such as frequency counters, DVMs, power supplies and signal generators. Programming, in Basic, is assisted by a standard teletypewriter keyboard with IEEE special function keys and a 40-character 5 × 7 fluorescent display. Software permits single-stepping through a program and through each IEEE character. Programs can be stored in a removeable PROM cartridge. This option, 001, has a storage capacity of 2 kbytes. An IEEE monitor indicates the status of control lines on LED indicators. A separate unit, the monitor can be used to verify IEEE cables or diagnose damaged bus circuitry. Model 3250 weighs only 9 lb and operates on 115/220 V ac, 50/60 Hz. Cost is $795. With option 001, the cost is $995. Delivery is 13 wks.

CIRCLE NO. 331



BUCKEYE CASES KNOBS

Attractive Designs
Unique Styles
Standard Sizes
Economy
Color Choices
Custom Piercing

SEE US AT NEPCON WEST BOOTH #438.

Matching Instrument Knobs

All types and sizes with the finest hot-stamped or silk-screened markings.

the BUCKEYE stamping co.
555 Marion Road
Columbus, Ohio 43207
614/445-8433

CIRCLE NUMBER 72 FOR CASES
CIRCLE NUMBER 140 FOR KNOBS

RF detectors fast delivery

Quantities to 200 from stock

You get fast delivery on WILTRON's quality RF detectors whether your needs are large or small.

And with discounts of up to 15% in quantity.

These are WILTRON's. time-proved quality detectors with field-replaceable diodes. Diodes are field-replaceable even in 18.5 GHz models.

Call Walt Baxter at WILTRON now for details.

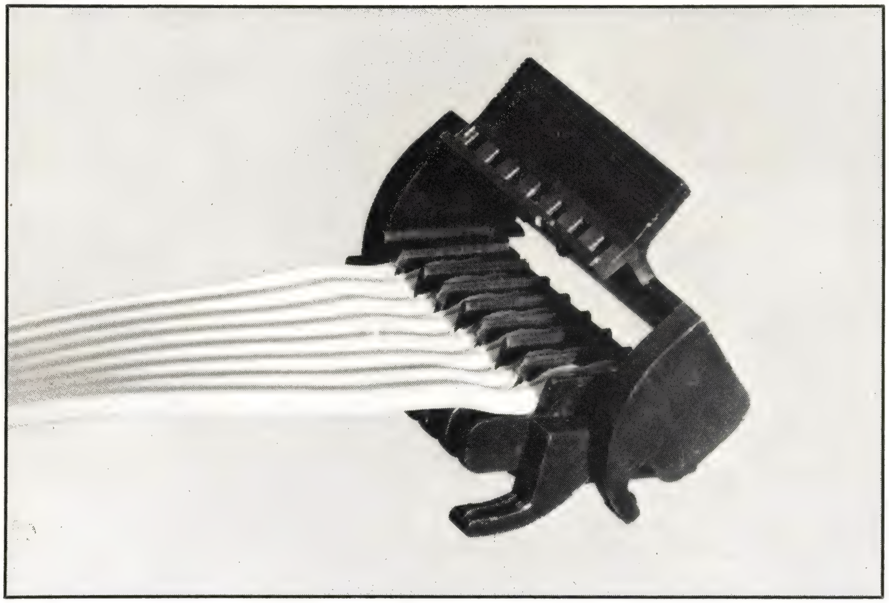
Model	Range	Connectors In	Connectors Out	Flatness	Price $
71B50	100 kHz-3 GHz	BNC Male	BNC Fem.	±0.5 dB	70
73N50	100 kHz-4 GHz	N Male	BNC Fem.	±0.2 dB	75
74N50	10 MHz-12.4 GHz	N Male	BNC Fem.	±0.5 dB	145
74S50	10 MHz-12.4 GHz	SMA Male	BNC Fem.	±0.5 dB	165
75A50	10 MHz-18.5 GHz	APC-7	BNC Fem.	±1 dB	210
75N50	10 MHz-18.5 GHz	N Male	BNC Fem.	±1 dB	170
75S50	10 MHz-18.5 GHz	SMA Male	BNC Fem.	±1 dB	170

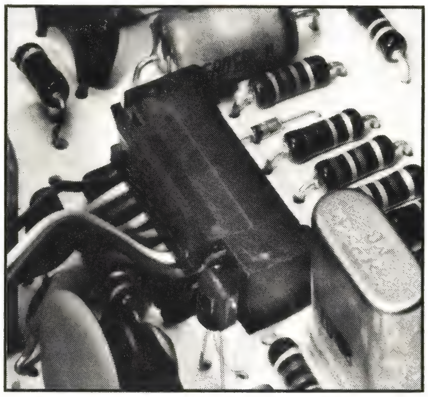
WILTRON

825 East Middlefield Rd. • Mountain View, CA 94043 • (415) 969-6500 • TWX 910-379-6578

CIRCLE NUMBER 73

Cable connector latches onto boards without soldering or socketing





The Midas Connector (left) has hooked feet which fit into predrilled PC board slots. Ribbon cable or discrete wires are placed between the cover and base. Closing the cover terminates wire and latches the connector to the PC board. The Midas takes up a minimum of board space.

T & B/Ansley, 817 Morse Ave., Schaumburg, IL 60193. John Williams (312) 893-8013. P&A: See text.

The Midas midboard connector provides an efficient, low-cost way to connect ribbon cable or discrete wires to PC-board contact pads—there is no need for soldering or costly header and socket assemblies. As a result, the zero-insertion-force connector should prove ideal where board space is limited, where the cable approaches the board at an unusual angle, and where daisy-chain couplings are desirable. Such applications include automotive controls, televisions and home entertainment consoles.

Eliminating the need for wire stripping and soldering as well as the construction of pin and socket-header assemblies greatly reduces the parts count and assembly time—and their costs. While parts inventory could cost easily one-quarter less than usual, assembly could cost as much as eight times less. Moreover, this type connector will take up half the PC-board space normally taken by discrete wires.

Several special design features also set the Midas connector apart. For example, a specially configured insulation-displacement contact provides four termination slots for each wire terminated; this increases the reliability of the IDC termination. The bottom side of the contact consists of a spring-loaded elbow, designed to provide high normal-contact forces with PC-board contact pads. The elbow will break through any oxide formation on the contact pad without increasing contact pad wear.

Other important design features include the connector's base and cover plates, which are made of glass-filled polyester and are UL-94 V-O-rated. The plates complete the IDC terminations and latch the connector to the PC-board contact pads, all in one operation.

The IDC, made of No. 688 brass alloy with 150-μin. tin plating, has a contact current rating of 4.5 A max, with No. 24 AWG wire. Contact resistance is 15 to 20 mΩ. In addition, the IDC will comfortably terminate 28 through 24 AWG solid or stranded wire.

To use the Midas connector requires a PC board 0.062 in. thick and circuit contact pads on 0.100-in. centers. Two dogleg-shaped slots, one at each end of the PC-board contact area, should be provided to accommodate the connector's latching feet. The contact area will be 3/4 in. wide and vary in length from 1-1/4 to 2-3/4 in., depending on the number of contact lines. Standard configurations of the Midas connector include 8, 10, 12, 14, 16, 20 and 24 positions.

Extensive environmental testing, moreover, has verified the integrity of the Midas contacts under a number of harsh environmental conditions. Contact resistance remains the same within 15 to 20 mΩ, after thermal shock (−40 to +105 C for 30 min., five cycles), humidity (95% RH for 96 hours at −40 C), vibration (10 to 55 Hz and back for 1-minute cycles), and thermal aging (80 C for 96 h).

The Midas connector will cost 3 to 4 cents per connector line. Production quantities will be available in the second quarter of 1980.

CIRCLE NO. 302

Stephan Ohr
Components Editor

You can count on AIRPAX.

"...a 7.25 amp two pole breaker with a red rocker handle? By Tuesday?!"

No problem. You have a choice.

You can flap around from distributor to distributor and probably get something pretty close to your specs.

Or skip the hassle. Call AIRPAX. Ask for HOTLINE delivery and get precisely what you need, built to order, at no extra charge.

It's your choice.

AIRPAX®

NORTH AMERICAN PHILIPS CONTROLS CORP.

Cambridge Division
Woods Rd., Cambridge, MD 21613
Telephone: (301) 228-4600

1979

Ultrasonics detect, locate and predict valve leaks

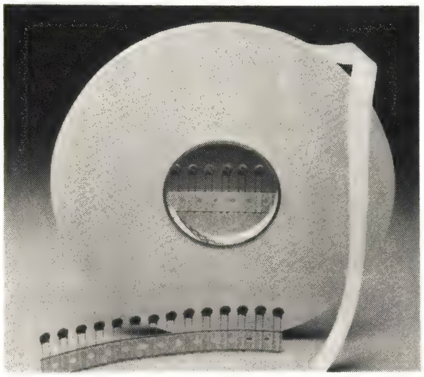
Physical Acoustics Corp., P.O. Box 3135, 743 Alexander Rd., Princeton, NJ 08540. (609) 452-2510. $4900; 30 days.

The AVLD-5120 dual-channel, acoustic leak detector quantizes acoustic activity near pressurized equipment. It can determine wear or damage to predict the performance and service life of critical valves, pipes and pressure vessels. Developed by the David Taylor Naval Ship R&D Center, the leak detector has been tested in naval installations for five years and is now available for industrial applications.

Acoustic emission sensors mounted on the surface of components detect inaudible high frequencies (ultrasound, from 10 to 200 kHz) that are generated by gas or liquid leakage and transmitted through the structure. The 5120 heterodynes the ultrasound down to the audible range. The operator can then listen and locate the sound source on the headphones or observe its acoustic-energy density on a analog meter.

CIRCLE NO. 303

Tape holds stand-up parts for automatic insertion



3M, Dept. IT9-22, P.O. Box 33600, St. Paul, MN 55133. (612) 733-1110.

A component tape, YR237, holds and protects radial-lead and stand-up axial-lead parts for automatic insertion systems. PC-boards can be automatically populated with such parts as disc capacitors, eliminating manual and sequencing operations. The tape uses a high-performance adhesive to lock and hold component lead wires to a flexible fiberboard carrier. Lead wire "floatation" is prevented. Widths of 1/2 and 3/4 in. are available in standard lengths of 360 yards.

CIRCLE NO. 332

ok WIRE FOR WIRE-WRAPPING ok

CUT TO LENGTH AND PRE-STRIPPED ON BOTH ENDS

AWG 30 (0.25MM) KYNAR® WIRE
INSULATION DIAMETER .0195 INCH (0.50MM)
STRIP-OFF LENGTH BOTH ENDS 1 INCH (25MM)
500 WIRES PER PACKAGE

AWG 28 (0.32MM) KYNAR® WIRE
INSULATION DIAMETER .023 INCH (0.59MM)
STRIP-OFF LENGTH BOTH ENDS 1 INCH (25MM)
500 WIRES PER PACKAGE

AWG 26 (0.40MM) KYNAR® WIRE
INSULATION DIAMETER .027 INCH (0.69MM)
STRIP-OFF LENGTH BOTH ENDS 1 INCH (25MM)
500 WIRES PER PACKAGE

LENGTH "L" INCH	AWG 30 BLUE PART NO.	AWG 30 WHITE PART NO.	AWG 30 YELLOW PART NO.	AWG 30 PRICE PER 500	AWG 28 BLUE PART NO.	AWG 28 WHITE PART NO.	AWG 28 YELLOW PART NO.	AWG 28 PRICE PER 500	AWG 26 BLUE PART NO.	AWG 26 WHITE PART NO.	AWG 26 YELLOW PART NO.	AWG 26 PRICE PER 500
1	30B-010	30W-010	30Y-010	$4.88	28B-010	28W-010	28Y-010	$5.25	26B-010	26W-010	26Y-010	$5.75
1.5	30B-015	30W-015	30Y-015	5.19	28B-015	28W-015	28Y-015	5.63	26B-015	26W-015	26Y-015	6.23
2	30B-020	30W-020	30Y-020	5.50	28B-020	28W-020	28Y-020	6.00	26B-020	26W-020	26Y-020	6.68
2.5	30B-025	30W-025	30Y-025	5.82	28B-025	28W-025	28Y-025	6.38	26B-025	26W-025	26Y-025	7.13
3	30B-030	30W-030	30Y-030	6.13	28B-030	28W-030	28Y-030	6.75	26B-030	26W-030	26Y-030	7.60
3.5	30B-035	30W-035	30Y-035	6.44	28B-035	28W-035	28Y-035	7.13	26B-035	26W-035	26Y-035	8.05
4	30B-040	30W-040	30Y-040	6.75	28B-040	28W-040	28Y-040	7.50	26B-040	26W-040	26Y-040	8.50
4.5	30B-045	30W-045	30Y-045	7.07	28B-045	28W-045	28Y-045	7.87	26B-045	26W-045	26Y-045	8.98
5	30B-050	30W-050	30Y-050	7.38	28B-050	28W-050	28Y-050	8.25	26B-050	26W-050	26Y-050	9.43
6	30B-060	30W-060	30Y-060	8.00	28B-060	28W-060	28Y-060	9.00	26B-060	26W-060	26Y-060	10.35
7	30B-070	30W-070	30Y-070	8.63	28B-070	28W-070	28Y-070	9.75	26B-070	26W-070	26Y-070	11.25
8	30B-080	30W-080	30Y-080	9.25	28B-080	28W-080	28Y-080	10.50	26B-080	26W-080	26Y-080	12.18
9	30B-090	30W-090	30Y-090	9.88	28B-090	28W-090	28Y-090	11.25	26B-090	26W-090	26Y-090	13.55
10	30B-100	30W-100	30Y-100	10.50	28B-100	28W-100	28Y-100	12.00	26B-100	26W-100	26Y-100	14.00

ROLLS OF WIRE

100 ft. roll	R30B-0100	R30W-0100	R30Y-0100	$3.65	R28B-0100	R28W-0100	R28Y-0100	$4.05	R26B-0100	R26W-0100	R26Y-0100	$4.35
500 ft. roll	R30B-0500	R30W-0500	R30Y-0500	10.40	R28B-0500	R28W-0500	R28Y-0500	12.85	R26B-0500	R26W-0500	R26Y-0500	13.80
1000 ft. roll	R30B-1000	R30W-1000	R30Y-1000	16.82	R28B-1000	R28W-1000	R28Y-1000	21.10	R26B-1000	R26W-1000	R26Y-1000	23.15

® KYNAR - PENNWALT

MINIMUM BILLING $25.00. ADD SHIPPING CHARGE $1.00. NEW YORK RESIDENTS ADD APPLICABLE TAX.

OK MACHINE & TOOL CORPORATION
3455 CONNER STREET, BRONX, N.Y. 10475 (212) 994-6600 Telex 125091

CIRCLE NUMBER 74

Reliability in precision technology.

Largest selection of Stepper, DC and Synchronous Motors

AIRPAX offers the largest selection of economical stepper and permanent magnet synchronous motors available anywhere. Whether you need a motor the size of a penny because of space limitations, or one powerful enough to drive an X-Y plotter . . . AIRPAX has it.

We have ironless rotor, brushless and permanent magnet DC motors for timing, drive and control applications. Plus shaded pole, reversible, lightweight synchronous AC motors for military or industrial applications. Also available are many instrument drive motors that can be provided with various gear trains. And a complete line of logic stepper motors from miniature to high torque types for use in computer peripherals and business machines.

In addition to this wide selection, all AIRPAX Motors are cool-running, reliable, low in cost and energy-efficient, too.

For a look at all of our motors and their specifications, write and ask for our free detailed literature.

AIRPAX™

NORTH AMERICAN PHILIPS CONTROLS CORP.

Cheshire Division
Cheshire Industrial Park
Cheshire, CT 06410
Telephone: (203) 272-0301

CIRCLE NUMBER 75 FOR IMMEDIATE NEED

CIRCLE NUMBER 76 FOR REFERENCE ONLY

Series 97-560
½″ wide double-twist, ideal for panel divider bar cabinets.

Series 97-500*
The original, ¾″ wide Sticky Fingers with superior shielding effectiveness.

Series 97-505*
A 90°-configuration version of 97-500.

Instrument Specialties' sticky fingers attach fast, shield against RFI/EMI!

Instrument Specialties' line of Sticky-Fingers beryllium copper gaskets provides *the* answer for just about every RFI-EMI problem.

Each strip is backed with a strong, *really* sticky self-adhesive that attaches quickly, grips and holds securely. There's no need to drill holes, no need for metal fasteners. You merely cut the strip to the desired length, peel the backing, and apply.

What's more, you get shielding effectiveness of up to 126 dB at 10 GHz plane wave, or greater than 90 dB at 1 MHz magnetic. Whether you want to keep interference in or out—in new installation or retrofits—there's a Sticky Fingers contact strip to do your job *better*! Special narrow strips (not shown here) are available where space is at a premium.

Our complete catalog of RF shielding strips and rings is available free. Write today to Dept. ED-92.

Series 97-538*
For maximum effectiveness at 10GHz plane wave; a bit less than 1″ wide.

*patented

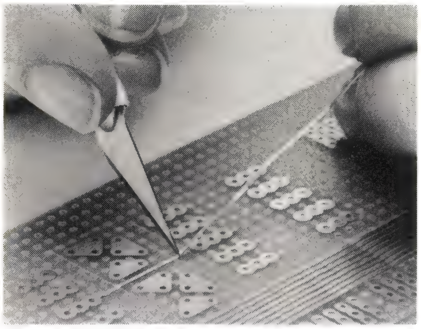
INSTRUMENT SPECIALTIES CO., INC.
Delaware Water Gap, PA 18327
Telephone: (717) 424-8510

Specialists in beryllium copper since 1938

CIRCLE NUMBER 77

Packaging & Production

Make PC boards without etching/artwork/chemicals

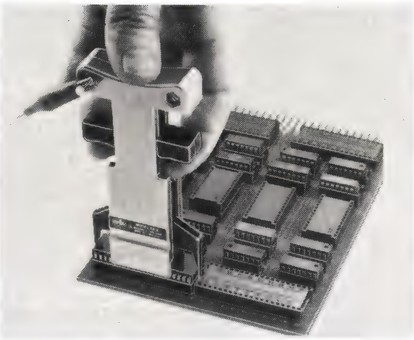


Bishop Graphics, 5388 Sterling Center Dr., P.O. Box 5007, Westlake Village, CA 91359. (213) 991-2600.

The E-Z Circuit line of PC board fabrication components speeds and simplifies packaging and prototyping. Pressure-sensitive copper mounting configurations, donut pads, tape and copper sheets permit PC board construction without etching, photography or artwork. Drilled, etched and pre-shaped boards complement the line. Compatible sockets, plugs, wire and wrap-wire pins are available.

CIRCLE NO. 333

IC extractor protects static-sensitive CMOS

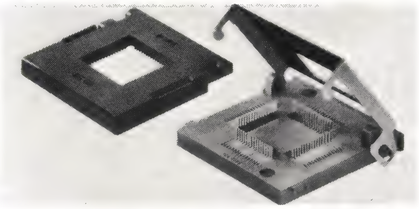


O.K. Machine and Tool, 3455 Conner St., Bronx, NY 10475. (212) 994-6600. $7.95.

Model EX-2, an IC extractor for 28 to 40-pin devices, uses heavy chrome plating for reliable static dissipation. A terminal lug for attaching a ground strap enhances protection for static-sensitive CMOS devices. The tool works on all 28 to 40-pin devices with standard 0.6-in. body widths. The mechanism is self-adjusting and gently lifts DIPs from sockets or boards using uniform pressure at both ends of the package.

CIRCLE NO. 334

Chip carrier sockets accept flat packs too

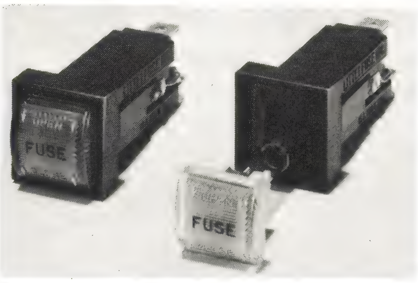


3M Textool Products, 1410 W. Pioneer Dr., Irving, TX 75061. (214) 259-2676. Typical $11.62 (socket); $1.15 (carrier) (100 qty); stock.

A socket/carrier test system series accommodates most leaded "chip carriers" and four-sided flat-packs. The series accepts a wide range of devices on 0.04-in. centers (up to 64 leads) and 0.05-in. centers (up to 48 leads). Although designed for holding carriers and packages measuring 0.75 in.^{2} and 0.6 in.^{2}, the series will accept other package sizes with only a minimum of tooling. Sockets have a lid design that eliminates shorting against contacts. Minimum lid overhang at the back of the socket permits maximum PC-board mounting density. Integral chassis mounting holes are provided.

CIRCLE NO. 335

Holders light way to faulty fuses

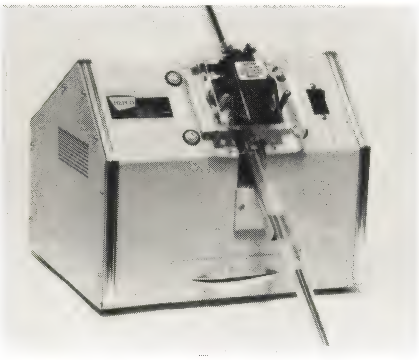


Littelfuse, 800 E. Northwest Hwy., Des Plaines, IL 60016. (312) 824-1188. $1.50 (OEM qty); stock.

Low-profile, square-cap fuseholders light when a fuse blows. The holders snap into a 0.625-in.^{2} mounting hole and extend only 1/2-in. from the front panel. Standard body and bezel color is black, but other bezel colors are available on special order. Series 344600 holders provide 3/16-in. combination quick-connect/solder terminals; Series 344800, 1/4-in. quick-connect/solder terminals. Neon lamps, for 120 and 240 V, or incandescent lamps, for 6, 14 or 28 V, can be ordered.

CIRCLE NO. 336

Cutting machine trims DIPs for fast insertion

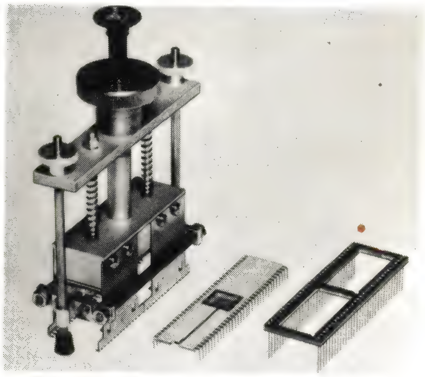


Hepco, P.O. Box 1009, Cupertino, CA 95015. (408) 738-1880.

A DIP lead cutting machine, Series 7400, increases production throughput by pre-trimming leads prior to PC-board insertion. Most commonly-used metal and plastic DIPs are accommodated. Pre-trimming speeds hand insertion rates by preventing bent-under leads. A typical lead cutting rate is 15,000, 16-pin devices per hour. Three models are available to accommodate 0.3, 0.4 and 0.6-in. DIPs.

CIRCLE NO. 337

DIP tools give TLC to VLSI packages



Micro Electronic Systems, 159 Main St., Danbury, CT 06810. (203) 797-1441.

DIP insertion and extraction tools, Sert-a-DIP and Lift-a-DIP, apply even force to the bodies of extra-large, 64-pin VLSI packages. Force on a device, using a high-performance socket, is about 1 lb/pin. Total force to insert or extract a device is well above 60 lb. The two tools spread the force evenly across the IC package to prevent damage to fragile ceramic bodies.

CIRCLE NO. 338

COIL SPRINGS
from Instrument Specialties last 100 times longer!

I/S compression springs were tested against competitive springs, based on specifications from a spring user. Samples of the spring were put in an oven at 200F, stressed equally at a moderate 27,000 lbs/sq.ft. Removed at intervals, the springs were then checked with standard loads at room temperature.

The competitive springs failed to meet the customer's load test after 2½ hours at 200F. I/S springs were still within tolerance after more than 200 hours and projections show they could have gone *1000* hours and remained in tolerance. Quite a testimonial to the advantages of hardening beryllium copper *after forming*, an I/S specialty!

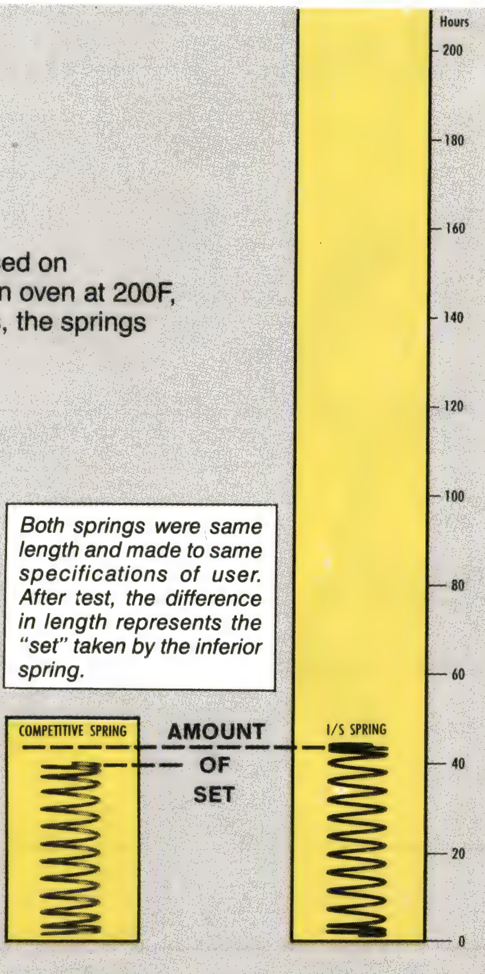
So, if you need coil springs with highest possible performance, test them at temperatures from 150 to 200F, under stress. We'll be happy to supply samples of ours for you to compare. Write on your letterhead, or phone us.

For a free catalog and manual on spring design, circle the Reader Service Card. Or write to Dept. ED-94.

INSTRUMENT SPECIALTIES CO., INC.
Delaware Water Gap, PA 18327
Telephone: (717) 424-8510

Specialists in beryllium copper since 1938

CIRCLE NUMBER 78



Both springs were same length and made to same specifications of user. After test, the difference in length represents the "set" taken by the inferior spring.

ASCII encoded keyboards as low as $42.*

The RCA VP-601 keyboard has a 58 key typewriter format for alphanumeric entry. The VP-611 ($10 additional*) offers the same typewriter format plus an additional 16 key calculator type keypad.

Both keyboards feature modern flexible membrane key switches with contact life rated at greater than 5 million operations, plus two key rollover circuitry.

A finger positioning overlay combined with light positive activation key pressure gives good operator "feel", and an on-board tone generator gives aural key press feedback.

The unitized keyboard surface is spillproof and dustproof. This plus the high noise immunity of CMOS circuitry makes the VP-601 and VP-611 particularly suited for use in hostile environments.

The keyboards operate from a single 5-volt, DC power supply, and the buffered output is TTL compatible. For more information contact RCA Customer Service, New Holland Avenue, Lancaster, PA 17604.

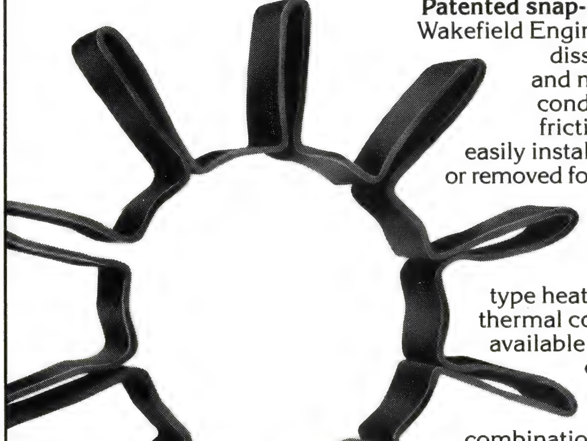
RCA

Or call our toll-free number: 800-233-0094.

*OEM price.

CIRCLE NUMBER 81

Dissipate more heat from your TO-5's.



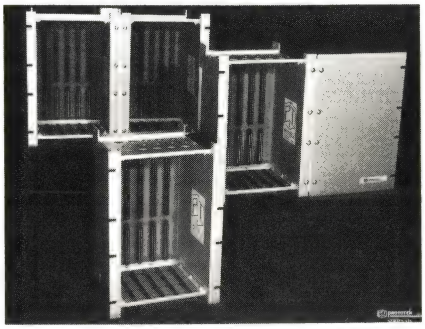
Patented snap-on coolers from EG & G Wakefield Engineering are the best heat dissipators for TO-5, TO-18 and many other similar semiconductor case styles. These friction mounted coolers are easily installed after wave soldering or removed for semiconductor replacement, and their spring-like-action, which is three to four times better than that of gear-type heat sinks, assures excellent thermal contact. Fourteen models available in aluminum, beryllium copper, or silver bearing copper. These patented coolers provide the best combination of excellent heat dissipation and vibration resistance, and are **only available** from E G & G Wakefield Engineering. That's why . . . if it has to do with heat dissipation . . . people throughout the electronics industry call us.

EG&G WAKEFIELD ENGINEERING

60 Audubon Road, Wakefield, MA 01880, 617/245-5900

CIRCLE NUMBER 82

Card-cage system aids SBC 80 prototyping



Prototek, P.O. Box 46512, Cincinnati, OH 45246. (513) 874-5094. P&A: See text.

A prototyping system for Intel SBC 80 compatible products, Series 126, builds on a modular card cage. A single 9-1/2-in. wide cage can be mated with a blank filler panel or a second card cage for mounting in a 19-in. rack. The cage is aluminum with a 1/8-in. epoxy glass backplane. Two wrap wire card configurations and an extender card complete the system. Dual-card packing densities of five at 1.2-in. and 11 at 0.6-in. spacing are accommodated. A card cage kit costs $200; a half rack panel, $22.50; an expansion kit, $20. Delivery is from stock to two weeks.

CIRCLE NO. 339

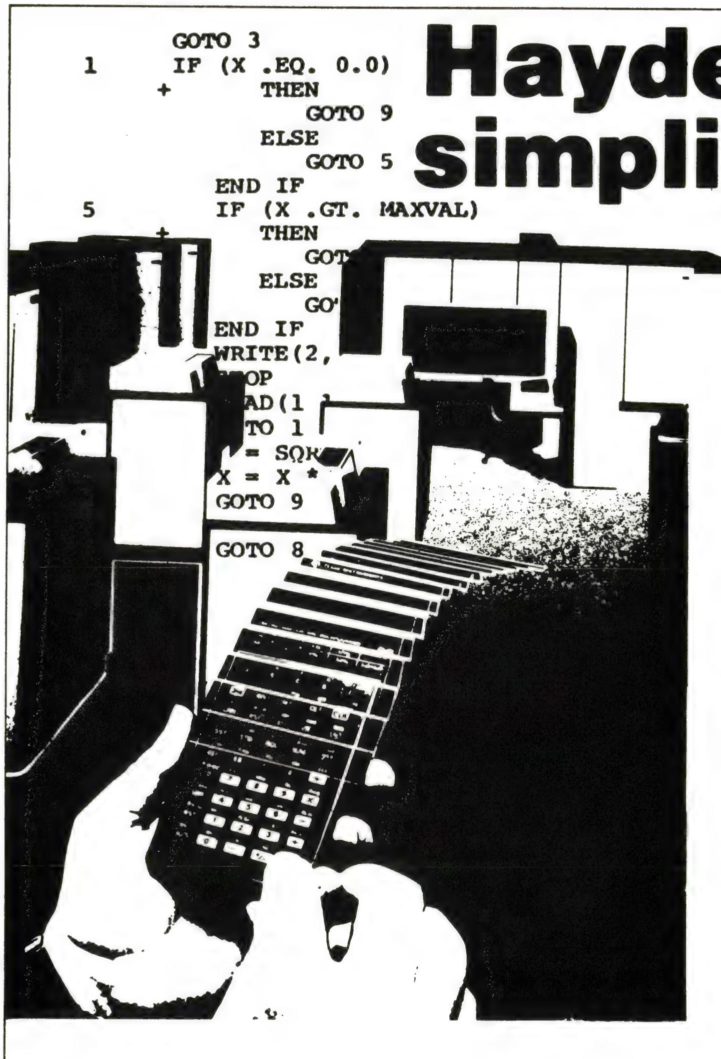
Float zoner increases yield on mono silicon

Siemens, 186 Wood Ave. S., Iselin, NJ 08830. (201) 494-1000.

A production float zoner, Model VZA9, obtains increased yields of swirl-free, zero-defect, high-resistivity mono silicon rods or wafers. The unit benefits producers of mono silicon used in power semiconductors and high-density microprocessors. A poly feed rod up to 6 ft long produces 4-in. diameter mono crystals against basic 3-in. material. Efficiency in converting poly to mono crystal silicon is 87%. Production capacity, based on a two-pass procedure, is 18 kg/day for 3-in. diameter mono crystals. Capacity increases if 4-in. material is used. The system offers automatic diameter and growth control, built-in crystal support and capability for vacuum or inert gas crystal growth. A mobile control desk permits convenient operational adjustments.

CIRCLE NO. 340

Hayden simplifies. . .



```
         GOTO 3
1        IF (X .EQ. 0.0)
     +      THEN
               GOTO 9
            ELSE
               GOTO 5
         END IF
5        IF (X .GT. MAXVAL)
     +      THEN
               GOT
            ELSE
               GO'
         END IF
         WRITE(2,
          OP
          AD(1
          TO 1
          = SQR
         X = X *
         GOTO 9

         GOTO 8
```

LARGE-SCALE COMPUTER ARCHITECTURE: Parallel and Associative Processors

(Thurber)

". . .an excellent selection of classic papers covering nearly 50 years of computer-related technical developments and concepts. . .very valuable as a reference. . ." *Computer Architecture News. #5775-X, cloth, $21.55*

. . .BASIC COMPUTER PROGRAMS FOR THE HOME

(Sternberg)

Brand new! A comprehensive book of practical home programs. Each program is documented with a description of its functions and operation, listing of the BASIC program, a symbol table, sample data, and one or more output samples. *#5154-9, paper, $10.95*

. . .PROGRAMMING PROGRAMMABLE CALCULATORS (Engelsohn)

Translates the jargon found in the manuals accompanying the machines into simple, clear instructions. Covers the SR-52, SR-56, TI-57, TI-58, TI-59, the Commodore PR-100, and the APF programmable model. Includes full sample programs and exercises with solutions. *#5105-0, paper, $10.75*

. . .LOGICAL DESIGN USING INTEGRATED CIRCUITS (Becher)

Provides a comprehensive introduction to logical analysis and design using integrated circuits. Begins with such topics as number systems and manipulative techniques, and concludes with combinational design, flip-flops, and other advanced topics. *#5859-4, cloth, $19.40*

...and satisfies your everyday needs!

1980 HAYDEN COMPUTER CALENDAR (Hayden Staff)

Contains 14 full-color, original computer works of art; a complete program in BASIC for a perpetual calendar; and computer anecdotes. This, the only calendar of its kind in the world, makes a great gift! *#5179-4, paper, $5.95*

ORDER YOUR 15-DAY FREE EXAM COPIES TODAY!

Write to: **HAYDEN BOOK COMPANY, INC.**
50 Essex Street, Rochelle Park, NJ 07662

ORDER CARD

Yes, I want Hayden to simplify my needs. Please send me the book(s) checked on 15-day FREE examination. At the end of that time, I will send payment, plus postage and handling, or return the book(s) and owe nothing. On all prepaid orders, publisher pays postage and handling —same return guarantee.

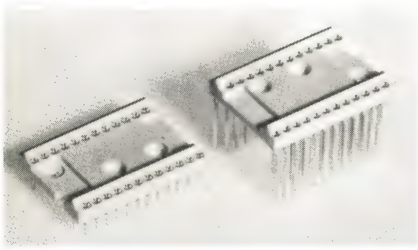
☐ #5154-9 **BASIC COMPUTER PROGRAMS FOR THE HOME**	$ 9.95
☐ #5105-0 **PROGRAMMING PROGRAMMABLE CALAULATORS**	$10.75
☐ #5859-4 **LOGICAL DESIGN USING ICS**	$19.40
☐ #5775-X **LARGE-SCALE COMPUTER ARCHITECTURE**	$21.55
☐ #5179-4 **1980 HAYDEN COMPUTER CALENDAR**	$ 5.95

Offer good in USA only. Residents of NJ and CA must add sales tax. Payment must accompany orders from p.o. boxes.

Send to:

HAYDEN BOOK COMPANY, INC.
50 Essex Street, Rochelle Park, NJ 07662

48-position header accepts QUIP devices

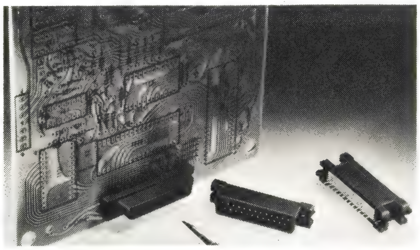


Garry Manufacturing, 1010 Jersey Ave., New Brunswick, NJ 08902. (201) 545-2424. $3.50 to $5.50 (small) qty); 2 to 4 wks.

Series 860 molded headers accept 48-pin quad-in-line (QUIP) packaged devices, including Motorola's QUIL family of bipolar LSI chips. The sockets are molded from Valox 420-SEO glass-reinforced polyester. Square wrap-posts or dip-solder terminals are available. Brass sleeves have a plating of gold or electro-tin over nickel. Four-tine beryllium spring clips use 25 μin. of gold plating over 50 to 100 μin. of nickel.

CIRCLE NO. 341

Plastic PC connector mates to standard D types

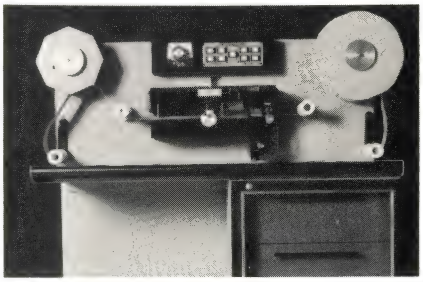


TRW Cinch Connectors, 1501 Morse Ave., Elk Grove Village, IL 60007. (312) 439-8800.

Plasticon, a plastic, polarized subminiature connector, fits into standard "D" type connectors. A snap-in mounting device, part of the Plasticon insulator, provides a quick, sure, hardware-free connection. The connector is available in a 25-pin arrangement with shell or contact polarization. Phosphor-bronze contacts are provided in various tail styles with gold plating. Maximum dimensions are 0.472 × 2.03 in. Contact resistance is 14 mΩ maximum; insulation resistance, 5000 MΩ minimum. Current rating is 3 A. Insertion force is 18 lb maximum. The connector will be customized to suit special requirements.

CIRCLE NO. 342

Taped parts handler makes contact for testing



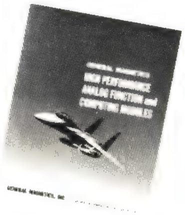
Q Corporation, 221 W. Market St., Derby, KS 67037. (316) 788-3746.

A reeled components handler, Model RTR2, provides reliable contacting for automatic testers. A high-resolution digital drive reduces jamming and eliminates component breakage. A short-throw contactor system minimizes nicking of component leads. Fully synchronous operation and fast index time allows a throughput as high as 120,000 components/h. Features include a precision optical lead finder for contact accuracy and automatic re-test for automatic recontact upon receipt of a fail indication from a tester. A failed component marker identifies part location. A component cutter removes failed parts from a tape.

CIRCLE NO. 343

THE LOGICAL SOURCE FOR HIGH PERFORMANCE ANALOG FUNCTION AND COMPUTING MODULES

For more information, write or phone for free catalog:



GENERAL MAGNETICS, INC.

211 Grove St., Bloomfield, NJ 07003
201-743-2700

① **3-Wire Synchro to Linear DC Converter.** Produces DC output voltage linearly proportional to synchro angle over ±180 degree range. Wide temp. range. 3-wire inputs ground isolated. ½% accuracy std., ¼% accuracy opt.

② **Precision AC Line Regulator.** Rugged and lightweight, stable over a wide temp. range. 0.1% total regulation with line, load frequency variations.

③ **Solid State DC to Synchro Converter.** Produces fully isolated 3-wire AC sinosoidal output proportional to a linear DC signal input. Accurate to 15′ of arc. Isolated reference input.

④ **Sine-Cosine Synchro Converter: Double Channel.** 2 separate sine-cosine synchro converter circuits. Converts 3-wire synchro input to pair of DC outputs proportional to sine and cosine of synchro angle with 6′ accuracy.

⑤ **Sine-Cosine Synchro Converter: Single Channel.** (Same as double channel, No. 4, but has only one converter circuit). Operating temp. range: −40 degrees C to + 100 degrees C.

⑥ **Demodulator.** Rugged. Solid State. Contactless Switching. Vibration and shock resistant. 0.1% conversion accuracy.

⑦ **Analog multiplier.** ½% of point product accuracy — best on the market. 2 MV offset over wide temp. ranges.

⑧ **Thermocouple Converter Modulator.** High voltage dielectric input isolation.

CIRCLE NUMBER 83

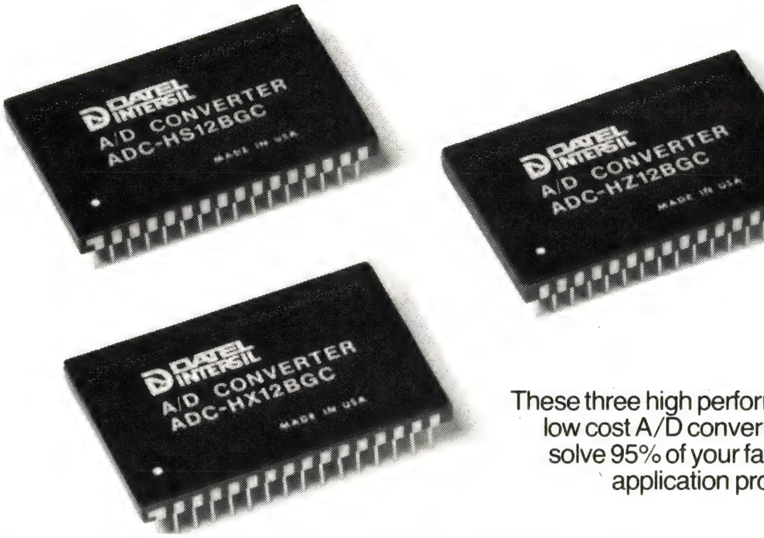
DATEL-INTERSIL

Three 12-Bit A/D Winners.

ADC-HX12BGC
12 Bits, 20 μsec.
internal input buffer

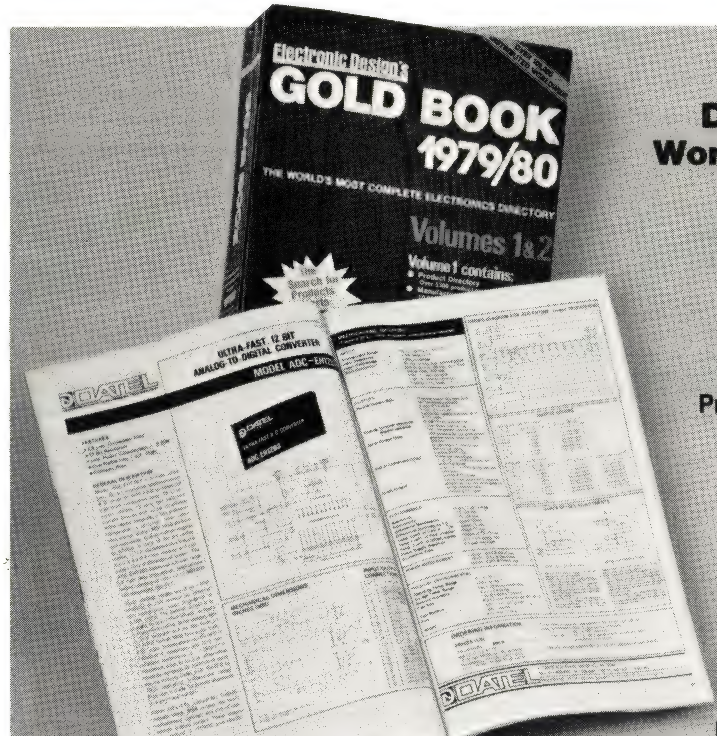
ADC-HZ12BGC
12 Bits, 8 μsec.
internal input buffer

ADC-HS12BGC
12 Bits, 9 μsec.
internal sample-hold



Other Features:
- Hybrid thin-film fabrication
- ½ LSB linearity
- 5 input ranges
- 20 ppm/°C gain tempco
- 32 pin package

These three high performance, low cost A/D converters will solve 95% of your fast 12 bit application problems.


Electronic Design's
GOLD BOOK
1979/80
THE WORLD'S MOST COMPLETE ELECTRONICS DIRECTORY
Volumes 1&2
Volume 1 contains:
DATEL
ULTRA-FAST 12 BIT ANALOG-TO-DIGITAL CONVERTER
MODEL ADC-EH12

Datel-Intersil and Gold Book. Working Together to Make Your Job Easier!

Together again for the 3rd year — Datel-Intersil and Electronic Designs Gold Book. Volume III of the 1979-80 Edition of Gold Book is the Datel-Intersil Engineering Product Handbook which contains complete specifications, product descriptions and application information.

So don't be delayed on your projects while waiting for product literature to arrive. Check the spec's in Gold Book today.

Electronic Designs, Gold Book the world's most complete electronics directory

DATEL INTERSIL

11 CABOT BOULEVARD, MANSFIELD, MA 02048 / TEL: (617)339-9341 / TWX 710-346-1953 / TLX 951340
Santa Ana, (714)835-2751, (L.A.) (213)933-7256 • Sunnyvale, CA (408)733-2424 • Gaithersburg, MD (301)840-9490
• Houston, (713)781-8886 • Dallas, TX (214)241-0651 OVERSEAS: DATEL (UK) LTD—TEL: ANDOVER (0264)51055
• DATEL SYSTEMS SARL 602-57-11 • DATELEK SYSTEMS GmbH (089)77-60-95 • DATEL KK Tokyo 793-1031

CIRCLE NUMBER 80

Test heads take ultralow current measurements

Santek, 4095 N. 28th Way, Hollywood, FL 33020. (305) 922-8282. Under $10,000 (5 qty).

Electrometer test heads perform ultralow current measurements using existing digital automatic test equipment (ATE). Accurate measurements can be performed as low as 1 fA with 0.1-fA resolution. The test heads retrofit any digital mainframe ATE, with or without autohandler. Typical application of the test heads include measurement of I_{gss}, I_{gon} and I_B in single and dual FETs and Bi-FET operational amplifiers. The heads are programmable, allowing a wide choice of product mix and limits. Although the heads cover from 1000 μA to 0.1 fA, most common designs are in the nA to pA level with three decades of range standard. A 1-pA measurement is accomplished in 50 ms.

CIRCLE NO. 344

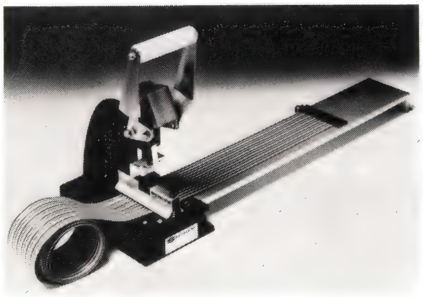
Tool rapidly removes ICs from burn-in boards

Reliability, P.O. Box 3709, Houston, TX 77036. (713) 492-0550. $3950; 6 to 8 wks.

A bench-mounted tool, the Un-Loader, rapidly removes socket-mounted ICs from burn-in boards and trays. The device is capable of removal rates of more than 6000 sixteen-lead ICs per hour. First of the line, Model 1217, removes devices from Robinson-Nugent Model S2 DIP sockets. In operation, unloading fingers, attached to a counterbalanced moving carriage, are aligned. A quick hand action moves the carriage over the board, removing ICs without bending leads or damaging packages. ICs are gravity-fed to self-contained reservoirs or into plastic or metal carrier tubes. Parallel rows of ICs can be removed in alternate passes of the carriage-mounted unloading fingers.

CIRCLE NO. 345

Cutting tool strips flat cable assemblies



Spectra-Strip, 7100 Lampson Ave., Garden Grove, CA 92642. (714) 892-3361. Under $100.

A portable cutting tool prepares flat cable assemblies of up to 64 conductors. The tool includes an assembly press, cutting blades and an extender bracket kit for positioning and holding cable.

CIRCLE NO. 346

BREECH-LOK® IS QUALIFIED TO MIL-C-38999, SERIES IV

BREECH-LOK®
G&H TECHNOLOGY, INC.

If you need high vibration resistance electrical connectors, call Ross Whitt right now at (213) 450-5604 for details. We're quoting 16-18 weeks delivery!

G&H TECHNOLOGY, INC., 1649 17th ST., SANTA MONICA, CA 90404

CIRCLE NUMBER 184

The common source for uncommon resistors.

The leader in high voltage metal film resistor technology is also your leading source for special resistor design and production. Victoreen offers proven technical excellence. Proven design excellence. Proven ability to understand your needs…and translate them into simple high performance, low cost answers. Also, you deal directly with Victoreen factory sales personnel so service is fast, less expensive, and enables you to become involved every step of the way. Have an uncommon problem? You'll find the uncommon solution at Victoreen. And that's common knowledge. Call or write:

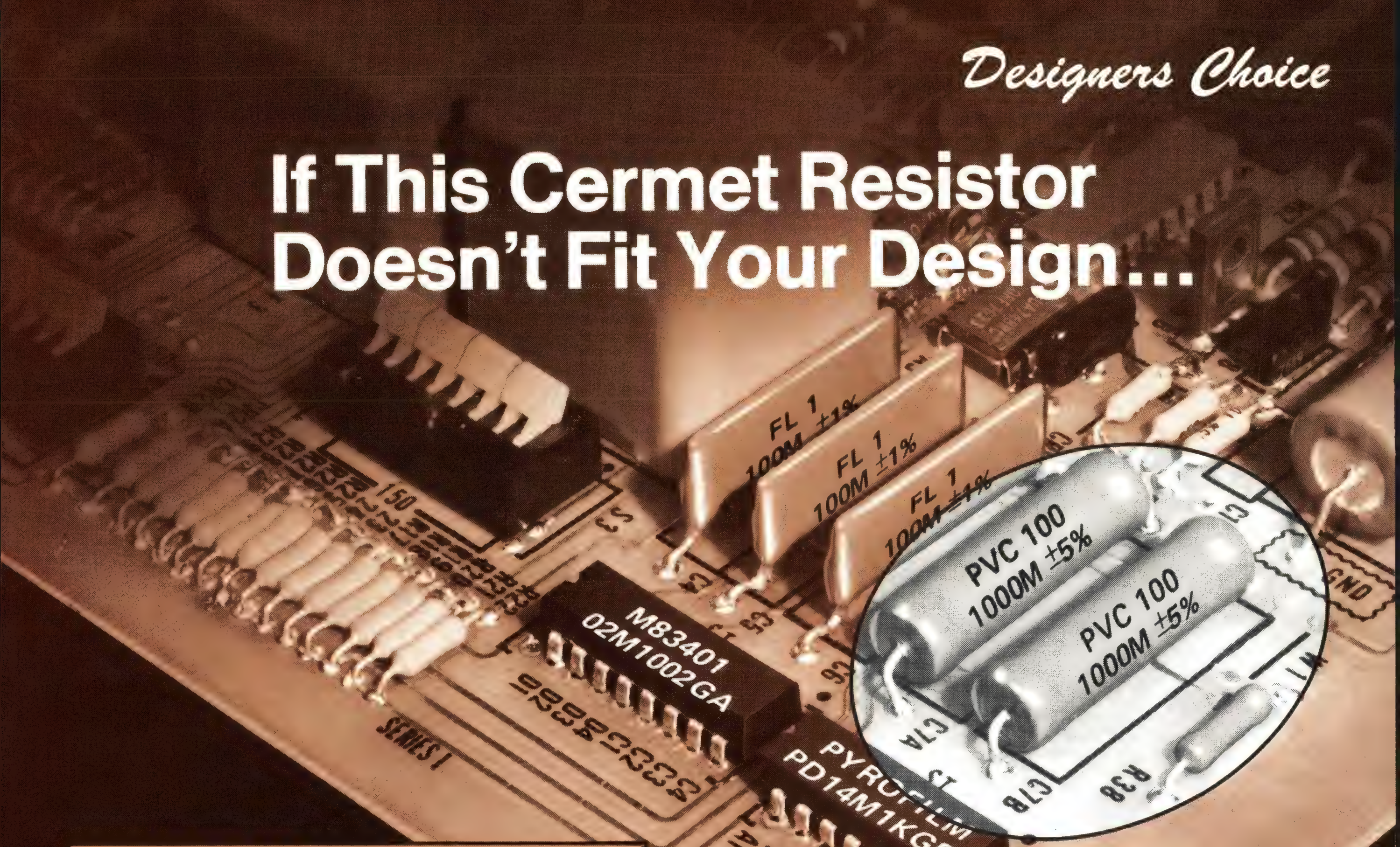
VICTOREEN

A Sheller-Globe Corporation Subsidiary
VICTOREEN, INC. 10101 Woodland Avenue, Cleveland, Ohio 44104
Phone: (216) 795-8200•TWX: (810) 421-8287

CIRCLE NUMBER 85

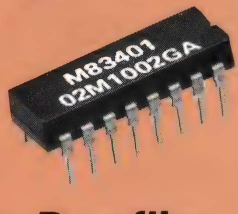
Designers Choice

If This Cermet Resistor Doesn't Fit Your Design...

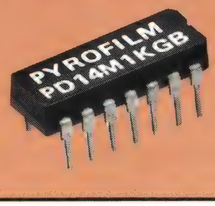


Try Pyrofilm... FLATSO's

Or Pyrofilm... MIL DIPS



Or Pyrofilm... DIP NETWORKS



PVC 7 Sizes to 40 KV • ¼ Watt to 5.25 Watts • 10 Kilohm thru 1,000 Megohm • TC's to ± 100 PPM/°C • 1,2,5, and 10% Tolerances

FLATSO 4 Sizes to 20 KV • ¼ Watt to 2 Watts • 50 Ohms thru 300 Megohm • TC to ± 250 PPM/°C • 1,2,5, and 10% Tolerances

MIL DIP KDI Pyrofilm QPL to MIL-R-83401 14 & 16 Pin • A & B Schematics • 27 Ohms to 100 Kilohms • ± 2 and ± 5% Tolerances

DIP NETWORKS 14 & 16 Pin • A & B Schematics • 10 Ohms to 1 Megohm • 1,2, and 5% Tolerances • Standard & Special Circuits

CUSTOM DESIGN For your unique set of thick film requirements, that, too, is the time to talk to a KDI Pyrofilm engineer.

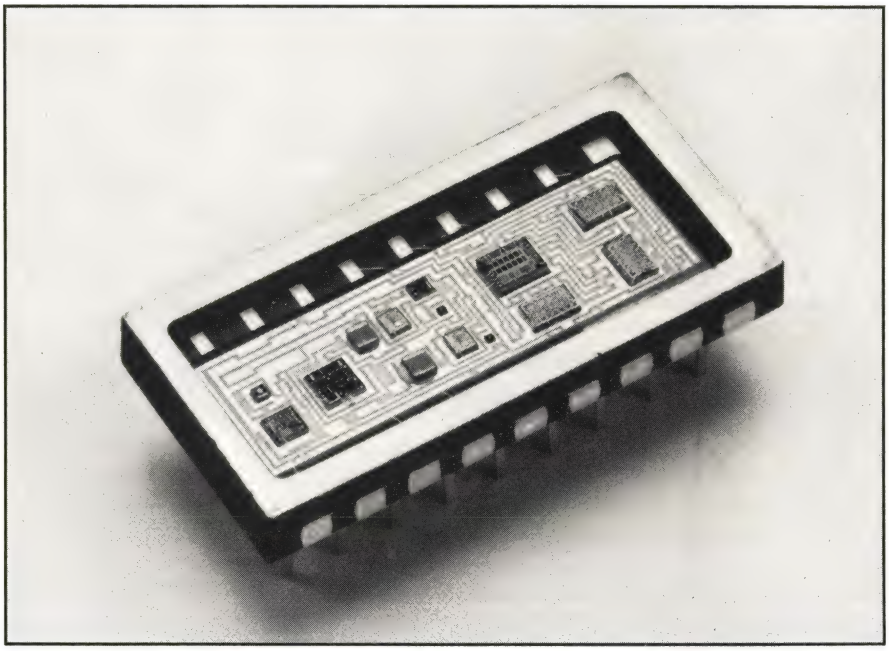
For complete details, contact KDI Pyrofilm Corporation, 60 South Jefferson Road, Whippany, New Jersey 07981, (201) 887-8100.

921

KDI PYROFILM

CIRCLE NUMBER 86

μP-compatible 10-bit DAC features fast input latches



Micro Networks Corp., 324 Clark St., Worcester, MA 01606. Chuck Sabolis (617) 852-5400. P&A: See text.

Interfacing with microprocessors in data-distribution systems comes easy to Micro Networks' 10-bit hybrid digital-to-analog converter, the MN3040. Besides having fast, TTL-compatible, on-board input latches, the 3040 packs the other required components—reference and output amplifier—to make it a self-contained converter.

The higher speed of its on-board latches is a definite advantage over other DACs. Three latch-timing parameters are critical—data-setup time, data hold time, and minimum enable pulse width—if a converter is to effectively interface with high-speed μPs. The 3040 offers 40 ns, 0 ns and 60 ns, respectively—much faster than other DACs.

The basic 3040 offers guaranteed performance over 0 to 70 C, while a military model, the 3040H, operates from −55 to +125 C. Both versions sport an absolute accuracy of ±0.4% over their respective ranges. And the output slew rate for both is 20 V/μs.

Two output-voltage-range options are offered: 0 to −10 V (unipolar) and ±10 V (bipolar). Digital input logic coding for unipolar operation is complementary binary, and for bipolar operation, complementary offset binary. Acceptable logic level input voltages are a minimum of 2 V for a logic ONE, a maximum of 0.7 V for a logic ZERO. This easily meets TTL level specifications. Settling time for a 20-V change (FSR is 20 V on ±10-V converters) is at most 5 μs to ½ LSB.

Monotonicity is also guaranteed over both operating-temperature ranges. The minimum load current available at the analog outputs is ±4 mA. Output impedance is typically 0.5 Ω. Power consumption for both models is 715 mW, maximum, 450 mW, typical.

Neither converter requires external adjusting potentiometers since both are actively laser-trimmed for linearity, gain and offset. Three power supplies are needed: +15, −15, and +5 V. Current drains—all maximums—are 20 mA for the +15-V, 11 mA for the −15-V and 50 mA for the +5-V supply.

In 100-piece quantities, the MN3040 costs $65, the MN3040H $110. Delivery takes four weeks.

CIRCLE NO. 304

WHEN HALF THE POWER

WILL DO THE WHOLE JOB!

If your application requires only moderate power, ENI's new Model A150 will do the job. All it takes is a laboratory signal generator and you've got a perfect match for RFI/EMI testing, NMR/ENDOR, RF transmission, ultrasonics and more. Capable of supplying more than 150 watts of RF power into any load impedance, the A150 covers the frequency range of .3 to 35 MHz.

We could mention unconditional stability, instantaneous failsafe provisions and absolute protection from overloads and transients, but that's what you expect from any ENI power amplifier, and the A150 is no exception!

For additional specifications, a demonstration, or a copy of our new, full-line catalog, contact ENI, 3000 Winton Road South, Rochester, New York 14623. Call 716-473-6900 or Telex 97-8283 ENI ROC.

ENI

The World's Leader in Power Amplifiers

CIRCLE NUMBER 87

"POWER-PACKED!"

OPTICALLY ISOLATED
AC SOLID STATE RELAY
in a 16-Lead DIP

SP 1100/2100 FEATURES

- High built-in transient immunity
- Zero volt switching
- 1.5 A Capacity; 120/240 Vac
- DTL/TTL Compatible input (LED)
- Very low leakage current (1mA)
- Dual SCR output stage

APPLICATIONS

- CONTROL motors, valves, heaters
- DRIVE lamps, solenoids, triacs/SCR's
- TRANSFER controller commands
- ACTIVATE alarms, signals, aux. circuits

Footprint matches C.P. Clare,
Teledyne and Theta-j Relays

Contact factory for information on other optically coupled relays and power monitors.

POWER INTERFACE INC.
3350 Scott Blvd., Bld. 34
Santa Clara, CA 95051
Phone (408) 727-1991
TWX 910-338-7819

PATENT PENDING

CIRCLE NUMBER 89

Driver/amp for MOSFETs does it all on one chip

Analog Systems, Box 35879, Tucson, AZ 85740. Rick Gerdes (602) 299-9831.

A 16-pin, DIP-packaged driver/amplifier from Analog Systems provides all the setup and driver circuitry for low and medium-power MOS semiconductors. The MA-500-CP is the first of a broad series of single-chip driver/amplifiers for power MOS devices.

Intended for audio amplifiers, servo controls, motor-drive circuitry and other limited-bandwidth, medium-power applications, The MA-500-CP can successively drive 10, 12, or 16-A power MOSFETS with a ±25-V maximum output, using a 30-V supply. The output of the MA-500-CP is invariably a voltage swing, which is connected with the high-impedance, voltage-sensing gate of power-MOSFET devices.

Amplifier gain is controlled by an external feedback loop, and is adjustable from unity through 1000, though higher gain products—as with any op amp—will generally produce limited bandwidths. A 7-MHz bandwidth, for example, is possible with unity gain. A gain of 50 will produce a bandwidth of 140 kHz; a gain of 5, a bandwidth of 1.4 MHz.

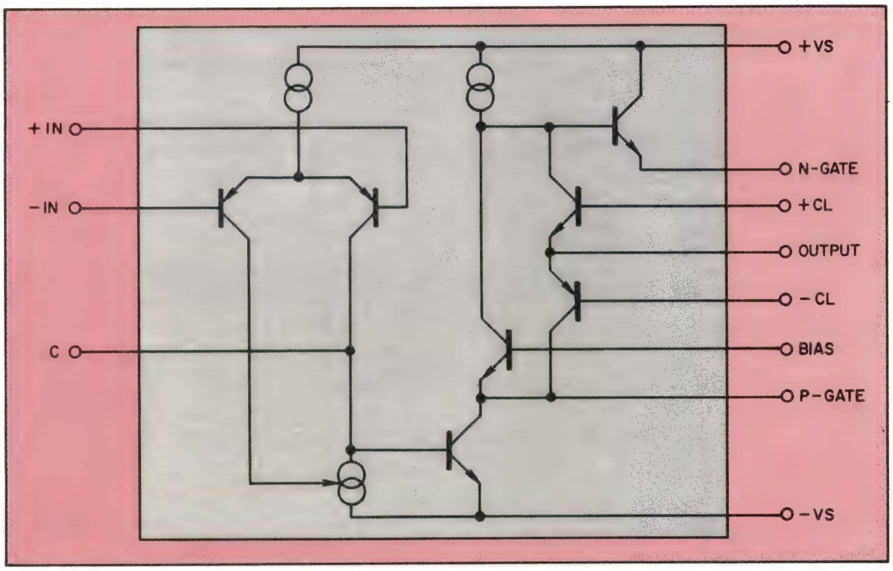
The open-loop gain of the driver/amplifier, however, is 104 dB. Moreover, the MA-500-CP employs a differential input, with a common-mode rejection of better than 90 dB. The slew-rate limit (for 100-kHz power bandwidth) is typically on the order of 17 V/μS with a ±25-V output swing.

The maximum temperature offset at the input is 30 μV/°C, which produces an insignificant—1.5-mV—offset at the maximum output. For audio-amplifier applications, the total harmonic distortion of an entire prototype power MOS amplifier unit measures less than 0.11% at full power under load.

The MA-500-CP consumes very little power: Input bias currents of preproduction prototypes measure less than 400 nA. What's more, while most MOSFET devices are self-protected, current-limiting circuitry is available on the chip simply by connecting an additional pin.

In OEM quantities, the MA-500-CP costs $2.65. Delivery takes from stock to four weeks.

CIRCLE NO. 305



The MA-500 features differential inputs, pin-programmable bias/current limiting, direct connections to n or p-Channel MOSFETs.

How to keep your test instruments honest.

Your test instrumentation won't deliver honest results unless its interconnecting accessories are up to snuff.

That's why ITT Pomona Electronics makes only top quality electronic test accessories you can really count on.

Our new, 100–page catalog tells it like it is. It's loaded with adapters, jacks, plugs, connectors, cable assemblies, test leads and much, much more.

To get a copy free, just write or call.

ITT Pomona Electronics, 1500 E. Ninth St., P.O. Box 2767, Pomona, CA 91766. Phone (714) 623-3463.

AVAILABLE THROUGH YOUR FAVORITE ELECTRONIC PARTS DISTRIBUTOR

Pomona Electronics ITT

CIRCLE NUMBER 88

Cambion Cage Jacks are ideal for mounting components or for function switching. No soldering or unsoldering—just snap in and out. They're quick, easy, and economical. Here's why CAMBION's the best:

contact—3 beryllium copper spring surfaces in a unique "cage" insure superior contact redundancy.

captivated cage—insures proper insertion/extraction force.

long life—up to 50,000 cycles of use.

selection—almost any component lead size, from .014 to .080".

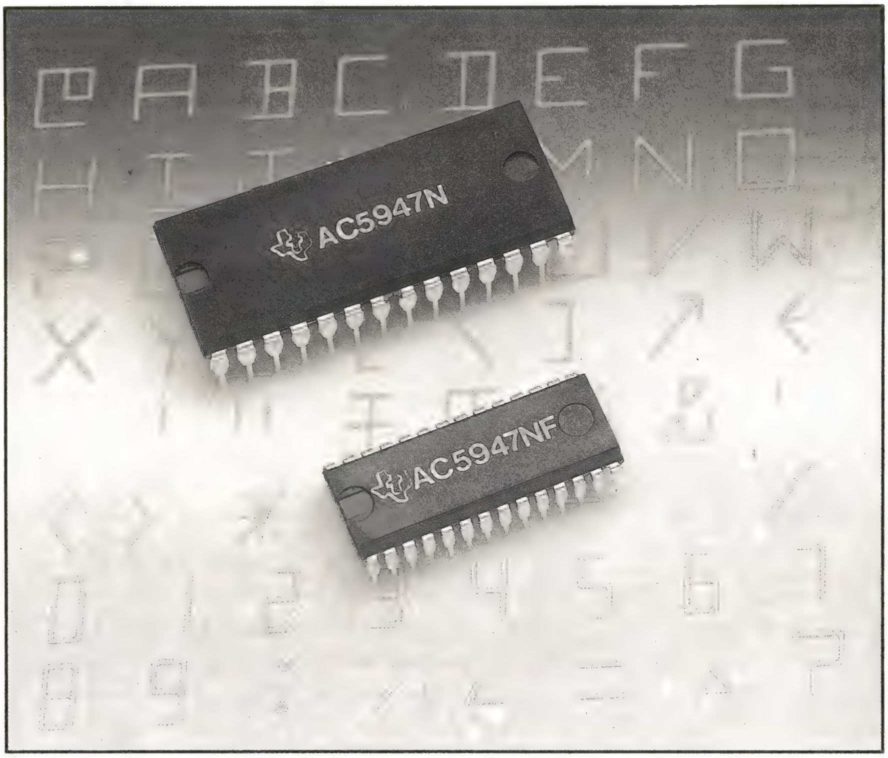
fast delivery—literally millions available from 54 distributors or directly from CAMBION.

For all the details, send for our FREE technical brochure. Cambridge Thermionic Corporation, 445 Concord Avenue, Cambridge, MA 02238. (617) 491-5400.

CAMBION®
The Right Connection.

CIRCLE NUMBER 91

Display drivers combine ASCII decoder and 18-segment drive



Texas Instruments, P.O. Box 6325, Dallas, TX 75222. Bob Weigel (214) 892-7029. $3.26 (AC9547N), $2.93 (5947NF); stock.

An ASCII decoder joins with all the circuitry necessary for 18-segment displays in the AC5947N from Texas Instruments. Fabricated with I^2L technology, the bipolar device handles 64 mA per segment. It accepts a 6-bit AS*y*II subset and contains input latches for applications in which the input data cannot be applied continuously.

The output drivers are npn emitter-followers that switch to $V/_{cc}$ −1 V to turn on each segment. External resistors limit the current for each output. One AC5947N drives up to 16 characters with external multiplexing. The circuit dedicates 18 pins for the segment drive; six for the input decoding; two for power and ground; one for an output-enable function; and another for clocking the input latches.

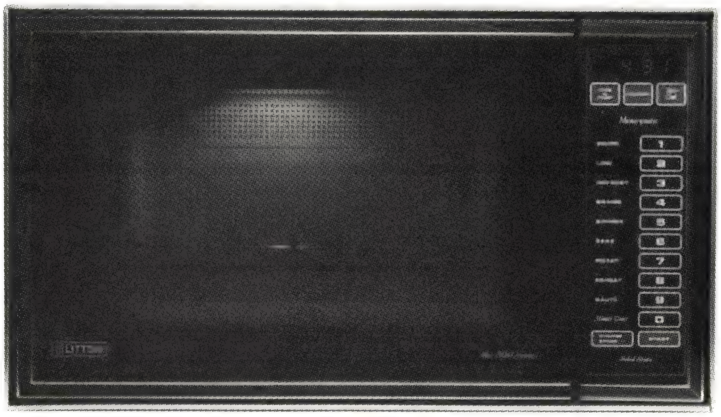
The circuit operates from a single 5-V supply. Its operating temperature range is −40 to 85-C (with an output current of −38 mA), and its temp range is 0 to 70 C with an output current of −64 mA, maximum, per segment. To latch data on the inputs, the AC5947N requires a minimum clock pulse width of 400 ns, a setup time of 350 ns and a hold time of 100 ns. When not driving any segments, the circuit draws a maximum of 3 mA from its supply.

Input-to-output switching characteristics include a decode delay of 15 μs, maximum, from the ASCII input to segment-driver output, and an enable delay of 10 μs, maximum, from enable input to segment-driver output. The output enable permits both display blanking and duty-cycle dimming.

The decoder driver comes in a standard 28-pin, 600-mil-wide DIP, in a package that measures 1.44 × 0.6 in. It is also available in a "shrink" version (the AC5947NF) that has pins on 70-mil centers, rather than 100-mil. The size of the package in this version is reduced to 0.99 × 0.4 in.

CIRCLE NO. 306

The PPG Touch.



It's PPG *Nesa*® and *Nesatron*® electronic glass. Incredibly versatile products with applications ranging from touch control panels to visual display devices.

A PPG *Nesa* glass touch control panel can replace virtually any electro-mechanical device. It's activated by the touch of a finger. And because there are no moving parts and nothing to break off, it simply does not wear out.

Then there's PPG *Nesatron.* Use it in a visual display device. It'll enhance any design with its sleek combination of function, durability and elegance.

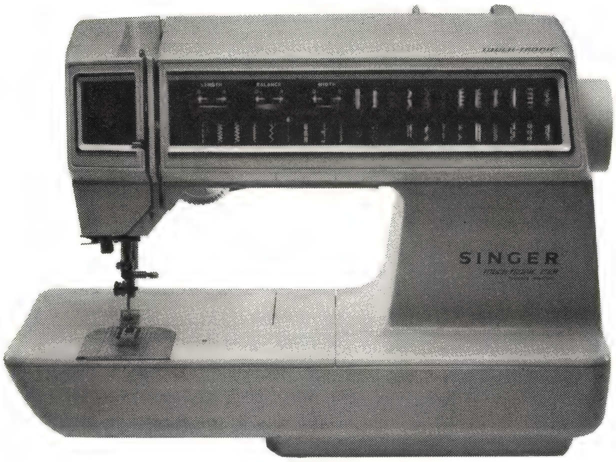
Consider the infinite present and future applications of both PPG electronic glasses: telephones, vending machines, microwave ovens, sewing machines, calculators, watches and instrumentation panels. The list goes on and on.

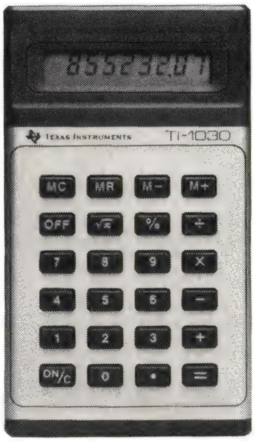
Learn more. Return the coupon today and start applying the PPG touch to your designs.

PPG: a Concern for the Future

PPG INDUSTRIES

CIRCLE NUMBER 90





Prototype model

Industrial Glass Products ED-120
PPG Industries, Inc.
One Gateway Center
Pittsburgh, Pa. 15222

Please send your technical and sales brochures about PPG *Nesa*® and *Nesatron*® electronic glass.

Name________________

Company________________

Title________________

Street________________

City________________

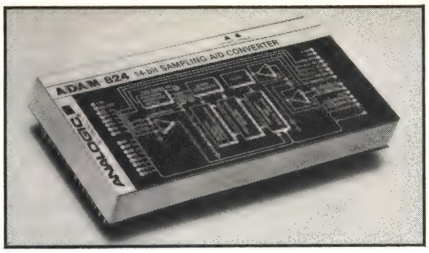
State________ Zip________

Telephone________________

Modular a/d converters include sample/hold circuits

Analogic Corp., Audubon Rd., Wakefield, MA 01880. Mark Annis (617) 246-0300. $299; 2 to 4 wks.

A successive-approximation a/d converter joins a precision sample/hold amplifier in one module—Analogic's A/D/A/M 824 or 825. The 14-bit 824 and 15-bit 825 sampling a/d converters perform better than systems made from discrete building blocks. The modules have a high throughput rate: 20 kHz or 20,000 measurements/s, including both sampling and conversion time.



An input programmable-gain differential amplifier and three-state bus-controllable latched-output registers are also on-board the 2 × 4 × 0.44-in. modules. Performance characteristics of the combined a/d and s/h circuits are accurate and stable. The differential nonlinearity of the 824 is 0.003% FSR, maximum, at 25 C. The temperature coefficient of differential nonlinearity is ±3 ppm/°C FSR, max, for the 824, and just ± 2 ppm/°C for the 825, also at 25 C.

Absolute accuracy for the 824, traceable to NBS, is calibrated to 0.006% FSR. Relative accuracy—the worst case summation of a/d and s/h nonlinearity errors—is a maximum of 0.005% FSR.

CIRCLE NO. 317

Power Products won't keep you waiting.

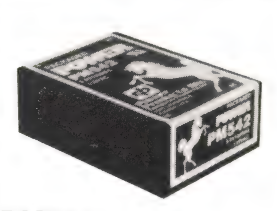
We ship all popular AC-DC power supplies within three days ARO.

±15V @ 200mA
- .02% Regulation
- 0.5mV RMS Ripple/Noise
- UL Recognized
- Two-year warranty **$45***

Power Products' exclusive Blue Streak Delivery System ensures quick shipment of prototype (1-3 piece) quantities. So you can power-up a new design sooner.

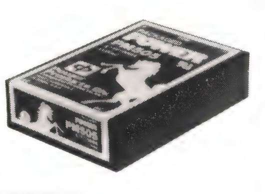
Choose from more than 50 standard supplies, like the popular models shown here. We stock single, dual, and triple output power supplies, featuring all popular outputs from 3.6 to 28 volts. Why wait? We can put the power in your hands in just three days from now!

Call or write for our free catalog before you're pressed for power. Or, if you need it now, order today. And ask for Blue Streak Service.



PM542

5.0V @ 1A. Regulation: ±0.02% Line/±0.04% load. 1.0mV RMS Ripple/Noise. Built-in overvoltage protection. Powers all popular digital logic. $45.00*



PM505

±15V @ 100mA. Regulation: ±0.02% Line/±0.02% load. 0.5mV RMS Ripple/Noise. 50 megohms input isolation. Ideal for powering op-amps and precision instrumentation. $33.00*

PM396

±15V @ 500mA. Regulation: ±0.05% Line/±0.05% load. 1.0mV Ripple/Noise. Chassis-mount model for use with linear IC and discrete analog circuits. $78.00*

(*OEM quantity price)

The Packaged Power Professionals

Power Products

Division of Computer Products, Inc.

1400 N.W. 70 ST./FORT LAUDERDALE, FLA. 33309 • (305) 974-2442/TWX 510-956-3098

CIRCLE NUMBER 92

Servo controller-on-a-chip drives model cars

Exar Integrated Systems, 750 Palomar Ave., Sunnyvale, CA 94088. (408) 732-7970. $4.45 (100 qty).

A complete servo controller system on a single chip, XR-2266, directs the operation of radio-controlled model cars. The monolithic IC contains two separate servo channels. One channel steers the car, the other controls the direction of travel and speed. The latter channel requires external power transistors; the steering channel is self-contained and provides ±350-mA drive. The circuit operates from battery supplies ranging from 3.5 to 8 V.

CIRCLE NO. 347

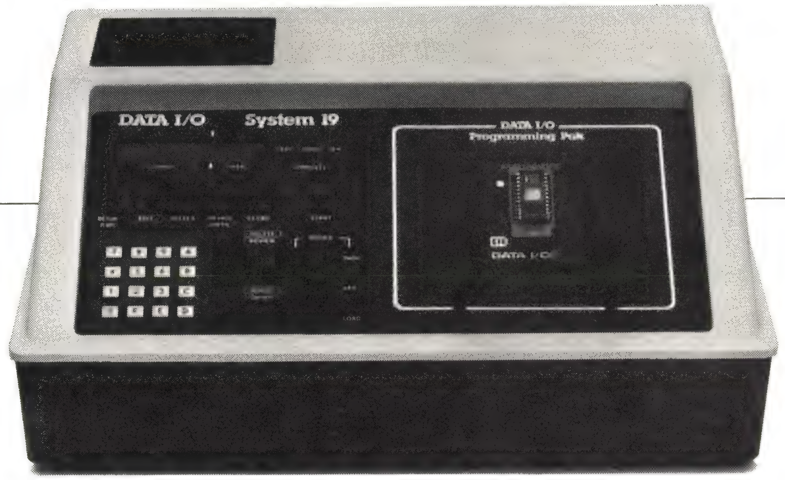
Video-speed a/d converter tolerates military use

TRW LSI Products, P.O. Box 1125, Redondo Beach, CA 90278. (213) 535-1831. $781 (100 qty).

An 8-bit, monolithic, video-speed a/d converter, TD*g*-1007J-M, operates over a case temperature range of −30 to +125 C. Applications include use in military radar and image acquisition systems. The device draws only 2.5 W while performing 30 million conversions each second.

CIRCLE NO. 348

"BEEP! BEEP!"



Data I/O's System 19 PROM programmer talks back to save you time and money.

It's a state of the art programmer that tells you when things are right, or if they're wrong, it tells you why.

Switch it on and the System 19 checks all its components: I/O port, microprocessor, RAM, bus, front panel and even its own software.

During the programming sequence, the System 19 conducts an illegal bit check, blank check, sum check on the newly programmed device and data verification at high, low and mid point voltages as required to make sure the device meets manufacturer's operating specifications.

The System 19 gently warns the operator when a simple procedural error is made and locks up before the operator can make a serious error and waste a device.

If something goes wrong during operations, the System 19 flashes one of 27 error codes on the readout to lead you to the specific problem quickly.

With a System 19, you can program every type of programmable logic device including FPLA. And with its unique gang module, you can program up to eight MOS devices at once.

Best of all, Data I/O's System 19 is priced within just about everyone's budget.

You haven't shopped around until you've looked at Data I/O. Let us show you the difference. Circle the reader service number or contact Data I/O, P.O. Box 308, Issaquah, WA 98027. ***For answers fast, call toll free: 800-426-9016.***

Good idea! DATA I/O

Programming systems for tomorrow...today

CIRCLE NUMBER 93

ANNOUNCING

Waters Anglyzer® Shaft Angle Position Readout

Waters announces the Anglyzer — a totally new concept in 360° shaft angle position measurement that features the infinite resolution and low noise of a precision conductive plastic potentiometer with a full 360° active angle. A novel integral solid state switching system combines two internal signals into one output over the full 360° to an accuracy of ±.36°. The Anglyzer provides a life of 100 million shaft revolutions at 1500 R.P.M. and may be used alone to provide a DC output proportional to shaft angle, or may be used with its companion Digital Readout as a total angle measurement/display system.

WATERS MANUFACTURING INC.

LONGFELLOW CENTER, Wayland, MA 01778 • (617) 358-2777

CIRCLE NUMBER 96

3, 3½, 4 & 4½ DIGIT AC & DC MINIATURE DPM's

- 2V/20V/200V or 1000V range.
- Range-change capability.
- Automatic polarity and overload indication.
- Programmable decimal.
- Input voltage protection.
- Power usage: 1.5W.
- Less than 1″ high.

PM-450—4½ Digits

SPECIFICATIONS

MODEL	RANGES	ACCURACY	AUTO POLARITY	MUX BCD OUTPUT	RATIO OPERATION	DIGITS	PRICES
PM-3	VDC - 1V, 10V, 100V or 1000V. PM-3.5, -349, -350, -351 & -450 have 100% over-range; 1200 (PM-3.5) and 1000V maximum. *Also has 200 mV Rng.	±0.1% F.S.	No	Optional	Optional	3	$ 99.50
PM-3.5		±0.05% F.S.	Standard	Standard	Standard	3-1/2	$109.00
PM-349*		±0.05% F.S.	Standard	No	No	3-1/2	$ 55.65
PM-350*		±0.05% F.S.	Standard	No	No	3-1/2	$ 69.55
PM-351*		±0.05% F.S.	Standard	No	No	3-1/2	$ 78.10
PM-4		±0.02% F.S.	Standard	Optional	Optional	4	$170.00
PM-450		±0.02% F.S.	Standard	Standard	No	4-1/2	$122.00
PM-3.5AC	VAC- 2V, 20V, 200V or 1000V	±0.5% F.S.	N/A	Standard	Standard	3-1/2	$150.00

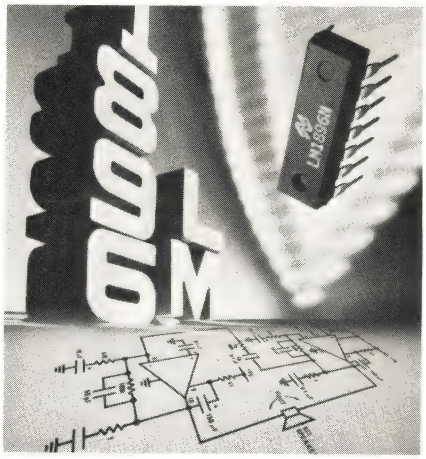
PM-351 has LCD display; all others LED display.

NLS products are available from Nationwide Electronic Distributors. Send for our brochure today!

Non-Linear Systems, Inc.
Originator of the digital voltmeter.
Box N, Del Mar, California 92014 Telephone (714) 755-1134

CIRCLE NUMBER 97

Audio amp IC solves AM radiation problem



National Semiconductor, 2900 Semiconductor Dr., Santa Clara, CA 95051. (408) 737-5000.

A stereo power amplifier, LM1896, reduces AM radiation, improving sensitivity and s/n performance in compact AM radios. The IC compensates for electromagnetic coupling of speaker and power supply leads to a radio's loopstick antenna. The result is a decrease in noise and system oscillation. LM1896 has noise-free turn-on and will operate from a 3-V supply. Distortion is typically 0.1% at 1 kHz for a 5-W output. The circuit typically delivers 1 W per channel into a 4-Ω load with a 6-V supply. Bridged for monaural operation, the device delivers 2 W into an 8-Ω load at 6-V. A higher-power device, LM2896, will be available in a SIP for use with supply voltages to 15 V.

CIRCLE NO. 349

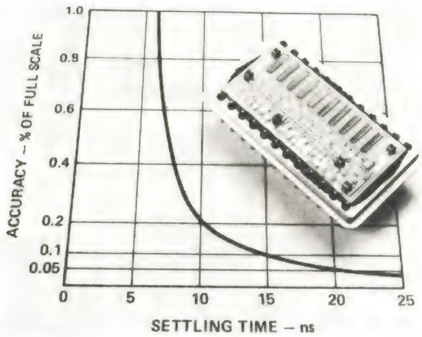
D/s converters drive three torque receivers

Computer Conversions, 6 Dunton Ct., East Northport, NY 11731. (516) 261-3300. Under $475 (OEM qty); 4 to 6 wks.

A 14-bit d/s converter, Part No. DSC40-PC-L-1, drives up to three, size 11, torque-receiver synchros with ±6 minute accuracy. The unit accepts a 14-bit natural binary angle and converts it to 3-wire synchro or 4-wire resolver signals. Output voltage is 90 or 11.8 V rms, 60 or 400 Hz. Current limiting, loading of 5 VA and short-circuit protection are standard. Digital inputs are TTL/DTL compatible. The synchro output and reference are transformer isolated.

CIRCLE NO. 354

Fast d/a converters drive 75-Ω video lines



Analog Devices Computer Labs, 505 Edwardia Dr., Greensboro, NC 27409. (919) 292-6427. $129 (8-bit); $149 (10-bit); stock to 3 wks.

Two hybrid d/a converters, HDS-0810E (8-bit) and HDS-1015E (10-bit), offer 10 ns and 15 ns settling times respectively. The devices directly drive a 75-Ω cable, providing 1 V pk-pk at the load. The converters make 100-MHz update rates possible for use in raster-scan and X-Y graphics, TV video reconstruction, digital VCOs, hf waveform generators and other high-speed applications. The ECL-compatible devices feature a low glitch energy of 200 pV-s and guaranteed monotonicity over the temperature range. Tempcos are 5 ppm/°C for zero offset and 80 ppm/°C for gain. Full processing to MIL-STD-883B is available. A single −5.2 V, 180-mA supply is required. The 24-pin package measures 0.8 × 1.31 × 0.2 in.

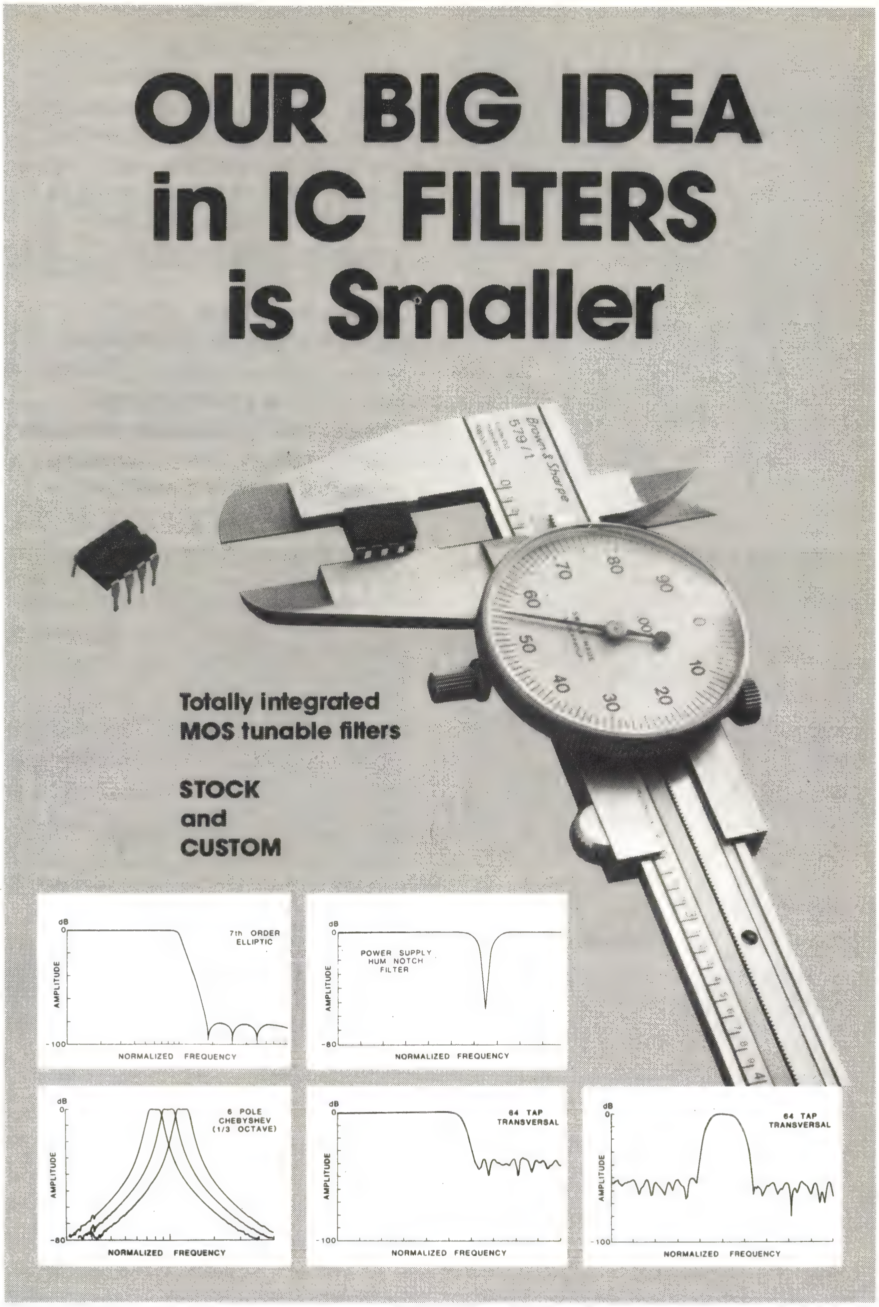
CIRCLE NO. 355

Radio-on-a-chip includes digital tuning circuits

NEC Electron, 3120 Central Expressway, Santa Clara, CA 95051. (408) 241-8222. $1.58 (100 qty).

A complete AM receiver subsystem on a single chip, UPC 1215V, includes provision for digital tuning. The device includes a mixer, a low-level oscillator, an i-f amplifier, a detector and station detector stages. Functions include internal agc for the first i-f stage, delayed agc for an optional external rf amplifier, an oscillator, a buffer amplifier to drive a logic section and a local/distance sensitivity control. Supply voltage range is 8 to 15 V dc; operating temperature range, −30 to +75 C. S/n ratio is typically 13 dB while harmonic distortion is rated at 0.5% typical. The chip comes in a 19-lead vertical plastic package.

CIRCLE NO. 356



Many filters immediately available in stock, custom designs also available:

- Multiple filters in single package — up to 50 poles
- Classical polynomial & ladder designs
- Linear phase with sharp edge rates
- Programmable Q as well as frequency

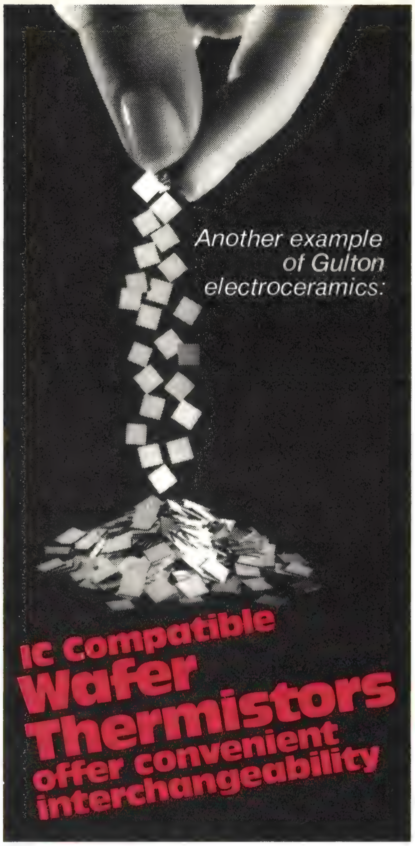
For complete details on this broad line of standard filters or on a custom design and how they can improve your product and reduce costs, call your nearest RETICON field office now.

EG&G RETICON

345 POTRERO AVENUE
SUNNYVALE, CA 94086
TWX: 910-339-9343

For assistance call: Boston (617) 745-7400, Chicago (312) 640-7713,
San Francisco (408) 738-4266, Tokyo, Japan 03-343-4411,
Bracknell, England (0344) 53618

CIRCLE NUMBER 94


Another example of Gulton electroceramics:
IC compatible Wafer Thermistors offer convenient interchangeability

Negative temperature coefficient (NTC) wafer thermistors provide high sensitivity plus...

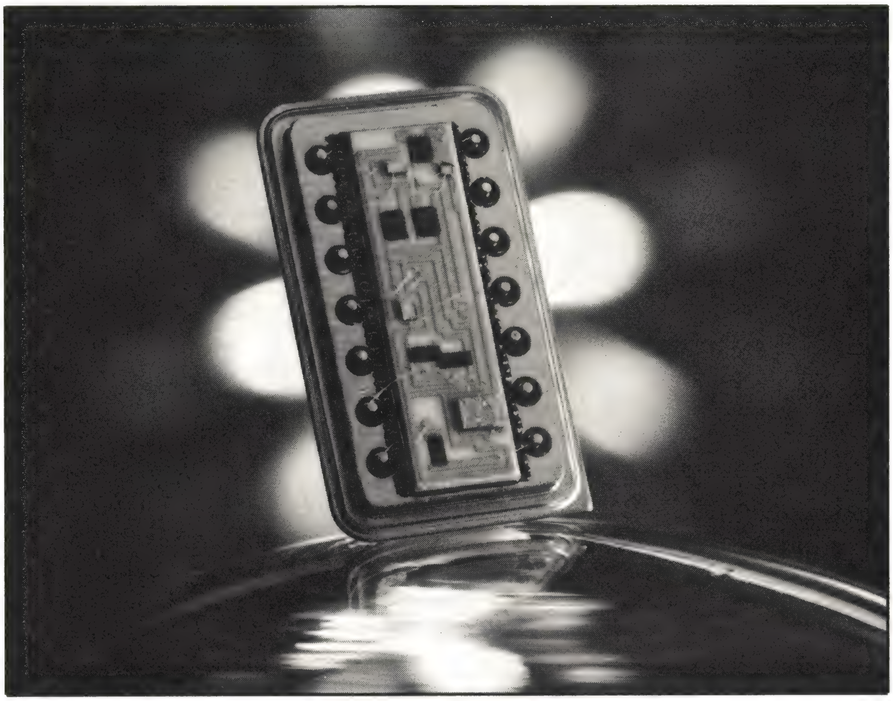
- resistance tolerances to ± ½%
- economical, reliable temperature measurements: −55° to +150°C
- fast, repeatable response
- convenient interchangeability—no part-to-part recalibration!

Call/write for information about these wafers or other thermistors—beads, chips, medical or specialized probes for sensitive measurements—included in our broad range of electroceramic products. Experimenter kits are available for your thermistor evaluation.

gulton®

Gulton Industries, Inc.
A dependable supplier of reliable thermistors
Piezo Products Division
212 Durham Avenue
Metuchen, NJ 08840
(201) 548-2800
CIRCLE NUMBER 98

Hybrid receiver/amplifier simplifies data comm



National Semiconductor, 2900 Semiconductor Dr., Santa Clara, CA 95051. (408) 737-5768. P&A: See text.

Reception of fiber-optic data communications now requires only a handful of external components, working with National Semiconductor's hybrid receiver/amplifier, the LH0082. Characterized by low noise and a low bit-error rate, the device offers a self-contained solution to a variety of short-hop data or analog communications needs, at T1, T2 and T3 telephone-link rates.

Internally, the circuit includes a 2-GHz gain-bandwidth FET-input amplifier, a 2.5-V reference, a comparator with hysteresis, and feedback and coupling resistors. The user selects the internal feedback resistors to set both gain and bandwidth. The amplifier's large gain-bandwidth lets it respond quickly even when high-capacitance photodiodes are used.

The receiver circuit works with a user's choice of photodiodes, p-i-n photodiodes, phototransistors, avalanche photodiodes and photomultipliers. Supply requirements are modest—only a single source, from 4.5 to 12 V. Power dissipation is just 500 mW. For compatibility with all systems, TTL, DTL and CMOS logic levels are accommodated.

With p-i-n photodiodes, data rates of 45 Mbits/s at 22 μW, 1 Mbit/s at 30 nW and 6 Mbits/s at 330 nW can be achieved with only a 10^{-9} bit-error rate.

Sensitivity is pin selectable at −45 or −35 dBm. In the high-sensitivity mode, assuming a photodiode sensitivity of 0.5 A/W, rise and fall time on a 30-nW analog input is 250 ns.

In the low-sensitivity mode, with comparable specifications, the figures are 70 ns and 300 nW. The noise floor, in both modes, is 0.5 nW. The amplifier section has a voltage gain of 80 V/V and an output noise of 200 μV over a 10-Hz to 10-MHz range. Output quiescent voltage drift is −6 mV/°C.

The hybrid circuit comes in a 14-pin, hermetically sealed DIP. A military version, LH0082D, is rated for service over a −55 to +125 C range. A commercial model, LH0082CD, performs from −25 to +85 C. Processing to MIL-STD-883 is available. In 100 quantity, LH0082CD costs $27; LH0082D, $41. Both are available in 10 wks.

CIRCLE NO. 307

If you haven't had a Model 3500 demo yet here are 7 reasons why you should.

Data Precision's Model 3500 5½ digit multimeter gives you more at reduced costs.

1. BCD Output and Digital Control

Parallel BCD output and digital control signal capability at *no extra cost.*

2. Ratio Measurements

DC/DC and AC/DC ratio measurement capability at *no extra cost.*

3. High Normal Mode and Common Mode Rejection

Model 3500 performance is significantly more effective in rejecting normal mode and common mode signals up to 80dB NMRR and up to 160dB CMRR.

4. Hi-Frequency Measurements

The Model 3500 AC voltage measuring capability is specified up to 100KHz.

5. High and Low Range ACV Measurement Capability

Provides a measurement capability of AC voltages on 5 range scales, including the low scale with 1μV resolution and a high scale to 700 volts RMS.

6. Zero Stability

Model 3500 incorporates Tri-Phasic ᵗᵐ auto-zeroing performance eliminating the need for zero adjustment between measurements on any range and any function.

7. Price

High quality performance and accuracy for $995 complete.

The Model 3500 has a 6 months basic DC accuracy of ±0.007% of reading ±1 LSD, full autoranging from 1 microvolt to 1000V (DC or AC peak) and 1 milliohm through 12 Megohms resistance, 20% overranging and an easy-to-read ½ inch planar display.

The Model 3500 also features our Tri-Phasic ᵗᵐ conversion cycle, Ratiohmic ᵗᵐ resistance mode, and Isopolar ᵗᵐ referencing, circuit techniques that increase performance and decrease price.

To arrange an immediate demonstration or for further information contact your local Data Precision representative or call:

(800) 343-8150, 892-0528 in Mass.

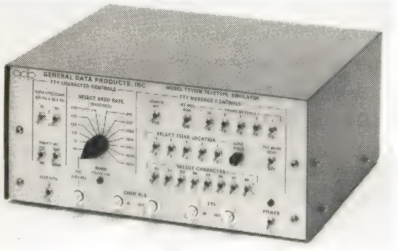
DATA PRECISION CORPORATION
Division of Analogic Corporation
Electronics Avenue, Danvers, MA 01923
(617) 246-1600
TELEX (0650) 921819

DATA PRECISION®
A DIVISION OF ANALOGIC CORPORATION

CIRCLE NUMBER 99 FOR DEMONSTRATION

CIRCLE NUMBER 100 FOR ADDITIONAL INFORMATION

Teletypewriter simulator tests TTY performance

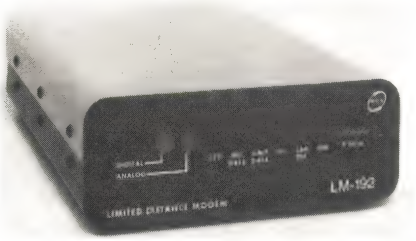


General Data Products, P.O. Box 159, Willow Grove, PA 19090. (215) 659-9125. $7385; 8 to 12 wks.

A teletypewriter simulator, Model TTYSIM, aids evaluation of TTY equipment and line performance. As a transmitter, the unit generates an internal or manually composed message. Operating as a UART, the simulator provides a bit-serial interface with a data source and/or sink. Features include choice of parity, word length and stop bits. Thirteen of the most widely used baud rates, as well as any external rate, are available.

CIRCLE NO. 357

Bargraph display assists modem equalization



Data-Control Systems, P.O. Box 860, Commerce Dr., Danbury, CT 06810. (203) 743-9241.

A front-panel LED bargraph display, part of the LM192 modem, aids line equalization. A built-in diagnostic distortion analyzer indicates line distortion in 5% increments from 0 to 50%. Other diagnostic features include front-panel status indicators and loopback capability. The modem operates at distances under 30 miles over private lines or local telephone circuits. All standard synchronous speeds are possible up to 19.2 kbits. The unit operates in point-to-point, multi-point or multi-drop environments. Rack-mount, desk-top and PC card versions are offered.

CIRCLE NO. 358

Smart, digital receiver spans vhf/uhf spectrum

Watkins-Johnson, 700 Quince Orchard Rd., Gaithersburg, MD 20760. (301) 948-7550. $22,500; 26 wks.

WJ-8617A, a digitally-controlled vhf/uhf receiver, operates with the power and flexibility of microprocessor control. Frequency range is 20 MHz to 1.1 GHz with 100-Hz resolution. Five detection modes are available: AM, FM, cw, pulse and ssb. Any of four i-f bandwidths, from 20 to 300 kHz, can be selected. Microprocessor control allows the receiver to accommodate multiple external interface options, as well as acquisition and decision-making capabilities within the receiver. Features include a digitally-refreshed display (DRD), scan/step mode and afc lockup on a captured signal. A 4-MHz wide spectrum display is built-in.

CIRCLE NO. 359

Vector PLUGBORDS OFFER MORE. . .

- Unique time saving bus patterns
- Press-fit wrap-posts & solder terminals
- Many board and contact sizes
- Easy to wire hole and pad patterns
- .042" diameter holes on .1" grid
- P.C. plug or flexcable connections

4493-1 ANY DIP, $23.88 Accepts all DIPs. Offset power and ground planes. 36/72 contacts. 4.5" x 9.6" (6.5" also available). 22/44 contacts also offered in both sizes.

8804 ANY DIP, $21.95. Accepts all DIPs. Offset power and ground planes, 50/100 contacts spaced .125." S-100 size.*

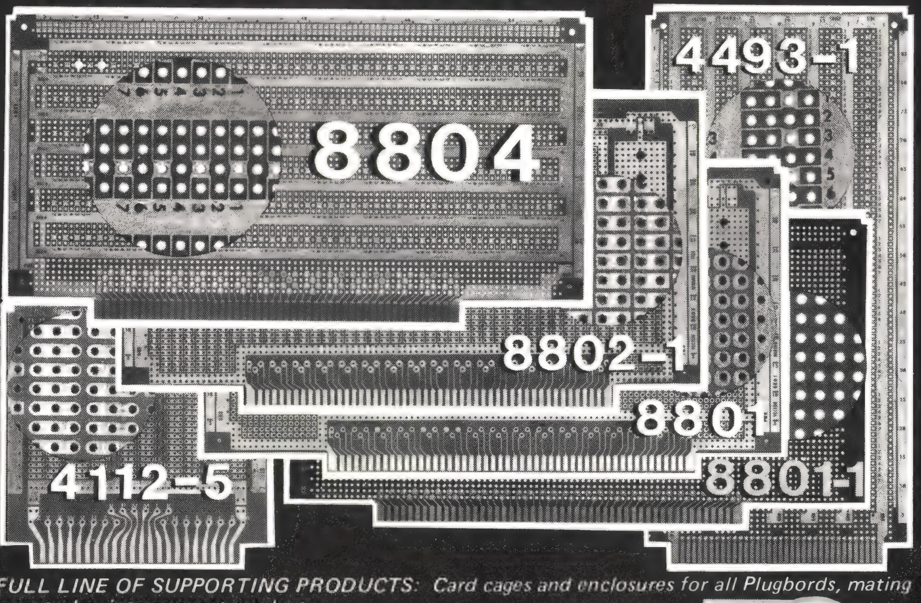
4112-5 PAD BOARD, $12.23. Pad per 3 holes. Ground plane on backside. 4.5" x 4.5" or 4.5" x 6.5" or 4.5" x 9.6". 22/44 contacts spaced 0.156".

8802-1 PAD BOARD, $23.99 Pad per 2 holes, each side, peripheral buses. 50/100 contacts spaced at .125", S-100 size.*

8801 PAD BOARD, $21.04 Pad per each hole, each side, peripheral buses. 50/100 contacts at .125". S-100 size.*

8801-1, $15.22. No pads — just holes. 50/100 contacts at .125". S-100 size.

*S-100 size is 5.3" high by 10" wide.

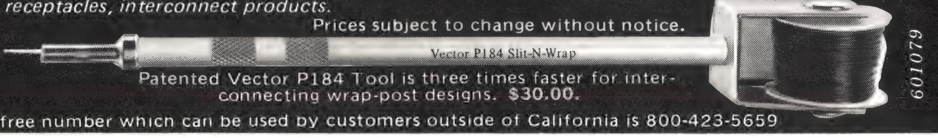


VECTOR ELECTRONIC COMPANY
12460 Gladstone Avenue
Sylmar, California 91342

Phone (213) 365-9661
TWX (910) 496-1539
Send for new data.

FULL LINE OF SUPPORTING PRODUCTS: Card cages and enclosures for all Plugbords, mating receptacles, interconnect products.

Prices subject to change without notice.



Patented Vector P184 Tool is three times faster for interconnecting wrap-post designs. **$30.00.**

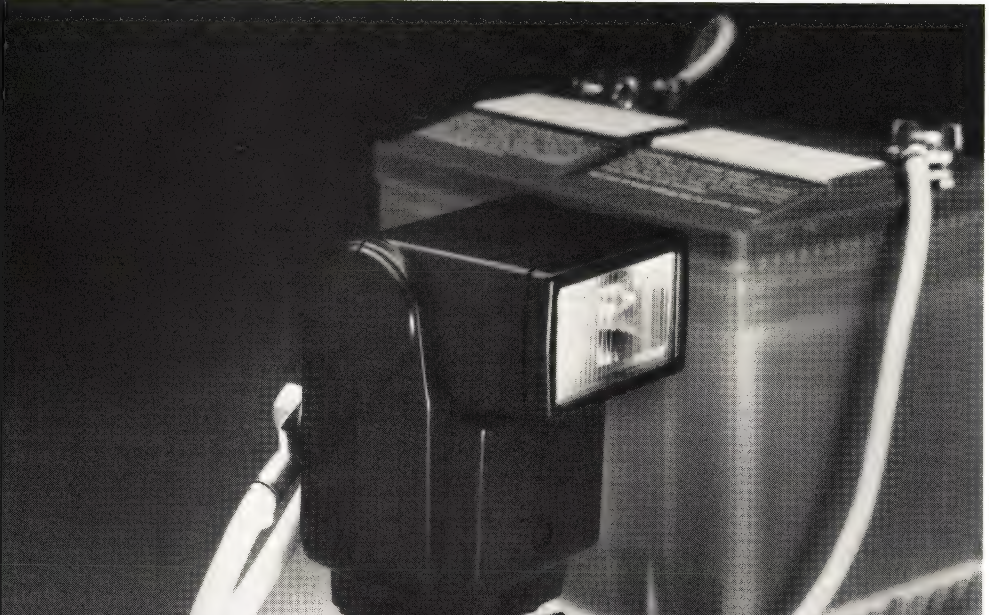
601079

Our toll-free number which can be used by customers outside of California is 800-423-5659

SEE EEM pp. 1329-1332

CIRCLE NUMBER 101

He should have used a CMOS Monochip.™



Here's another good idea that didn't quite make it because the designer didn't choose the right technology for his circuits. If he had used CMOS, he could have cut the power consumption, size, and weight of the finished product.

And with Monochip, he could have had his CMOS prototypes in just 6 weeks for under $5000.

That's because Monochip's circuit components—the first five layers—are already in place. All you do is tell us how you want them connected for your application.

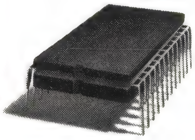
Working from your layout, we'll etch the sixth layer to produce your prototype. When you've approved it, we'll make from 5000 to half a million parts for you.

Our $59 Monochip Design Kit has everything you need to lay out your own CMOS IC. And free help from our CMOS experts is as near as your phone.

Now you can have the advantages of custom CMOS IC's without paying $50,000 and waiting a year for full-custom development. Break through to CMOS technology today with Monochip, the semi-custom IC.

Call or write today for more information. Interdesign, 1255 Reamwood Avenue, Sunnyvale, CA 94086. (408) 734-8666.

Interdesign



Monochip:™
the semi-custom IC.

Our $59 Monochip Design Kit has everything you need to develop your own CMOS IC. You choose the size—from 100 to 400 gates.

Interdesign is a Ferranti Company.

CIRCLE NUMBER 102

Modem operates over 4-wire line at 9600 bits/s

Rixon, 2120 Industrial Pkwy., Silver Spring, MD 20904. (301) 622-2121. $6300; 4 wks.

A Bell-compatible modem, T209A transmits and receives synchronous serial data at 9600 bits/s over a four-wire private line. Inputs from up to four synchronous data sources can be multiplexed into a composite 9600 bits/s stream. Multiplex combinations include four 2400 bits/s streams, one 4800 and two 2400 bits/s streams, two 4800 bits/s streams or one 7200 and one 2400 bits/s streams. Diagnostics include three front-panel switches for analog loopback, digital loopback and self-test. Eleven indicator lights are provided for fast isolation of system malfunctions. The modem comes in a stand-alone, desktop enclosure, but may be converted for rack mounting. Options include an integral C829 four-wire termination card and a monitor card to determine received signal data quality.

CIRCLE NO. 363

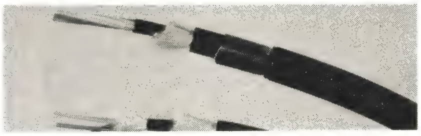
IR light beam links computers up to 328 ft

Scientific Radiation, 1201 San Antonio Rd., Mountain View, CA 94043. (415) 965-0910. $395/pair (12-V); $455/pair (ac); 2 wks.

A complete, infrared, optical communications system, Model 5010 Optodata, carries two-way computer data at distances of 328 ft (100 m). A LED source can be safely viewed with no eye damage. The 9000-Å light beam easily penetrates airborne condensation and particulates. Data rate extends to 2400 baud. The units are housed in rugged aluminum enclosures and are sealed against moisture and dust. Either 117 or 230-V ac power can be used. Battery operation is possible from 12 or 24-V sources.

CIRCLE NO. 364

Tough fiber cables take direct burial



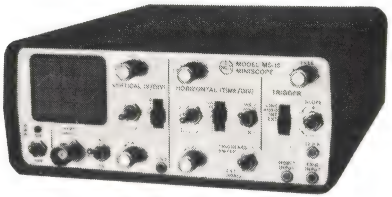
ITT Electro-Optical Products, 7635 Plantation Rd., Roanoke, VA 24019. (703) 563-0371. $0.63 to $1.25/fiber/m; stock to 9 wks.

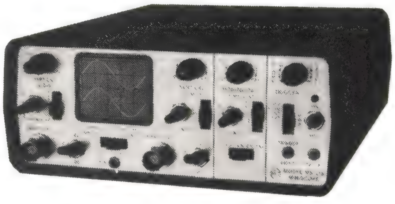
Heavy-duty fiber optic cables withstand tough environments for medium to high-performance voice, video and data transmission. The rugged cables have 150-kg tensile strength and can be used for intra-building, aerial, duct and direct burial. A heavy-duty version incorporates fibers with jacketed diameters of 1 mm. Void-filling aluminum-tape armor is offered as an option. A general-purpose cable uses fibers with jacketed diameters of up to 0.5 mm. Both cable types are supplied with up to 19 fibers. The heavy-duty version is suitable for plowing-in or trenching using standard cable installation techniques. Lengths of up to 1 km are standard. Longer lengths are provided on special order.

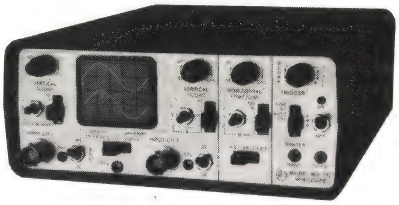
CIRCLE NO. 365

MUNIFICENT MINISCOPES!!

● For electronic professionals on the go. ● Prices that please. ● Greatest selection. ● Now!! 30-MHz bandwidth in the new dual-trace Model MS-230.







MS-15 $349.80
15 MHz —Single-Trace
- External & internal trigger.
- Line synchronization mode.
- Power usage—<15 W.
- Battery or line operation.
- 2.9″ H x 6.4″ W x 8.0″ D.

MS-215 $465.45
15 MHz — Dual-Trace
- External & internal trigger.
- Line synchronization mode.
- Power usage—<15 W.
- Battery or line operation.
- 2.9″ H x 6.4″ W x 8.0″ D.

MS-230 $598.15
30 MHz — Dual-Trace
- External & internal trigger.
- Line synchronization mode.
- Power usage—<40 W.
- Battery or line operation.
- 2.9″ H x 6.4″ W x 8.6″ D.

NLS products are available from Nationwide Electronic Distributors.
Send for our brochure today!

NLS
Non-Linear Systems, Inc.
Originator of the digital voltmeter.
Box N, Del Mar, California 92014 Telephone (714) 755-1134

CIRCLE NUMBER 103

Outstanding Performance by an under $30* DPM

The Gralex Model 30

- Full Performance, 3½ digits
- Exceptionally Bright, 0.5" LEDs
- Flat Profile Case - only ¾" deep
- 5 Vdc; 1W power
- Model 35: AC powered equivalent

*250: $29.50
1-24: $39.50

actual size

Formerly Manufactured by Fairchild Camera and Instrument Corp. Now made by Gralex.

GRALEX INDUSTRIES

DIVISION OF GENERAL MICROWAVE CORPORATION
155 MARINE ST., FARMINGDALE, N.Y. 11735
Tel. 516-694-3607 • TWX 510-224-6406

Also available at these distributors:
ARIZONA, Meter Master, Inc., (602) 243-4111 • **CALIFORNIA,** Meter Master, Inc., (213) 685-4340, Meter Master, Inc., (415) 968-0313, Meter Master, Inc., (714) 560-4841 • **ILLINOIS,** Meter Master Inc., (312) 593-8650 • **MASS,** Meter Master, Inc., (617) 667-8346 • **NEW MEXICO,** Century Electronics, (505) 292-2700 • **NEW YORK,** Summit Distributors, (716) 884-3450 • **TEXAS,** Meter Master, Inc., (214) 271-5671 • **CANADA,** Montreal, Quebec, Future Electronics, (514) 735-5775

CIRCLE NUMBER 104

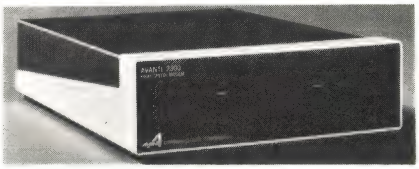
6-GHz amplifier pumps power into satellite uplink

Hughes Electron Dynamics, 3100 W. Lomita Blvd., Torrance, CA 90509. (213) 534-2121.

A high-power amplifier subsystem, Model 9740H02, performs redundantly or in a power-combining role in satellite uplink service. The system, using a ruggedized metal-ceramic travelling-wave tube (TWT), provides 330-W output in its redundancy mode and 650 W when used as a power combiner. Minimum bandwidth is 500 MHz at 6 GHz. As a standby unit, the amplifier can be in a "hot" mode with the unit fully operational into a dummy load. In a "warm" or beam-off mode, the heater is operated at lower power to increase TWT life. Integral forced-air cooling is provided.

CIRCLE NO. 366

High-speed modem sends data over twisted pairs

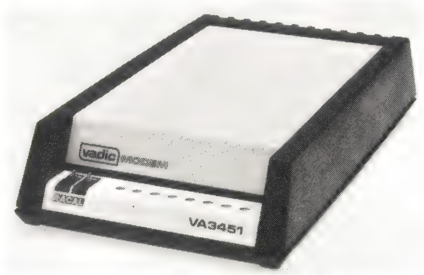


Avanti Communications, Aquidneck Industrial Park, Newport, RI 02840. (401) 849-4660. $2750.

A high-speed modem for computer-to-computer bulk data transfer, the Avanti 2300, operates over unloaded twisted pairs or coaxial cables at distances to 7000 ft. Data rate is 1.544 Mbits/s or 3.088 Mbits/s. Operation is full-duplex, four-wire, point-to-point, with internal or external timing. Error rates are better than 10^{-9}. The unit includes on-line self-test capabilities. An operator is alerted to a failure anywhere along a data link via a front-panel alarm light. A scrambler makes transmission insensitive to data format. Digital interface is CCITT V.35 or, optionally, EIA RS422. Stand-alone or rack-mount versions are available with a redundant power supply.

CIRCLE NO. 367

Triple modem gives choice to remote terminal users



Racal-Vadic, 222 Caspian Dr., Sunnyvale, CA 94086. (408) 744-0810. From $900; 8 to 9 wks.

VA3450 series, triple modems for remote terminal use, combine a Bell-type 212A and type 103 modem with a VA3400 modem in a compact, stand-alone package. A single modem satisfies all conventional originate/answer applications for switched-network, full-duplex data transmission from 0 to 1200 bits/s. The series includes six models, all of which are registered for direct connection under Part 68. An originate or answer version is offered for leased-line use. A called modem is automatically identified. Diagnostics include idle test, analog loopback and busy-out, digital loopback and self-test.

CIRCLE NO. 368

It's spillproof.

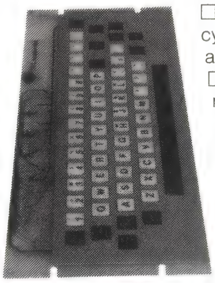
New from TEC
Low cost, low profile
Micro-Motion™ Keyboard

The front surface of the Micro Motion Keyboard is sealed with a Polycarbonate Material, making it impervious to most accidental spills.

For areas where harsh chemical environments exist other overlay materials are available.

Features

☐ Tactile feel ☐ Custom design, unlimited colors optional ☐ Embossed keys on velvet surface ☐ Positive mechanical contacts ☐ LED indicators in keys for specific key functions, optional ☐ All versions sealed from front, environmental back sealing optional ☐ Enclosure optional ☐ Mounting on .093" (.236 cm) PCB for rigidity.



Less than .125" (.317 cm) thick

☐ Contact life in excess of 5,000,000 cycles ☐ ASC II or EBCDIC encoding available ☐ Parallel output standard ☐ Serial output optional ☐ 3 or 4 modes of operation available on intelligent models ☐ "ALL CAP" key electronically latched on intelligent models ☐ CMOS optional ☐ Direct soldering, terminals, PCB tab, Flex tail, or Connector interface available. Standard model has a 34 pin header.

Major Applications

1. Process Control
   Machine shop environments; paper mills; textile industries; Oil and associated drilling rigs.
2. Home Computers
   Low cost applications where fast data entry is not required.
3. Any application where severe environmental conditions exist.

Ask about our other Keyboards too!

TEC, Incorporated
Corporate Headquarters:
2727 N. Fairview Ave.
Tucson, Arizona USA 85705
(602) 792-2230/TWX 910-952-1377/Telex 16-5540

TEC International, Inc.
European Sales Office:
Avenue Louise 148—Box 6, 1050 Brussels, Belgium
(02) 649 81 54/Telex 846-63553

CIRCLE NUMBER 112

BESIDES SHIELDING OUT INTERFERENCE, METEX ALSO SHIELDS YOU FROM STATIC.

"Baxter! If you don't solve, that interference problem, I'm going to interfere with your paycheck.

You get enough static on the job every day.

So the last place you need static is in the electronic products and systems you design.

Metex knitted metal and elastomeric shielding can help you avoid both types of static.

Metex has been a leader in developing shielding solutions for almost as long as there have been shielding problems.

We supply EMI/RFI shielding products to leading manufacturers in virtually every industry.

All of whom are pretty demanding customers. With demanding performance, delivery and cost requirements. Including very close after sale support and service requirements.

One of the reasons we've managed to get our foot in the door of these industries is because we haven't bolted out the door when tough problems came up.

WE UNRAVEL PROBLEMS. AND KNIT SOLUTIONS TO THEM.

Instead, we've knitted together innovative solutions to them. And stayed with the engineer and the product through production and long after delivery to make sure things work.

As a result of our problem solving capabilities, we now have the largest line of shielding products available anywhere in the world.

Including our Metex Shield Vu® Window. Omni Cell® Panels. Xecon® Conductive Elastomer. Metex EMI/RFI Shielded Modular Raceways. And Combo® or Pola® Shielding Gaskets.

We also have the best instruction materials.

Our video seminars are the only ones that are given free.

And our 124-page EMI/RFI Shielding Handbook, also available free, is recognized throughout the world as the textbook of the field.

Our point is simply this:

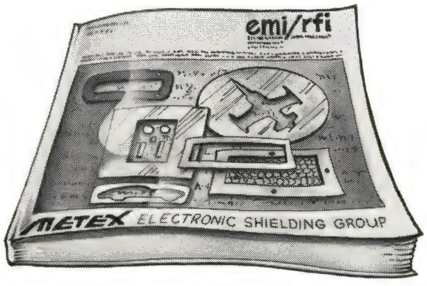
If you have an interference problem, there is no one better equipped to come up with an economical solution to it and deliver it on time than Metex.

And there's no one more willing to work with you after the sale to make sure the problem stays solved.

You're not through with Metex after delivery. Just knowing that can help you avoid a lot of static at the office.

To find out more about us or our shielding products, write or call: Metex Electronic Shielding Group, a unit of Metex Corporation, 970 New Durham Rd.,Edison, N.J. 08817. (201) 287-0800.

Or 20437 S. Western Avenue, Torrance, Calif., 90501. (213) 320-8910.



To get your free 124-page handbook, write to us on company letterhead.

METEX

ELECTRONIC SHIELDING GROUP

Copyright, Metex Corporation, 1979. All rights reserved.

CIRCLE NUMBER 105

Molded-to-spec elastomer keyboard cuts parts cost and wear

Conductive Rubber Technology, 1230 Coast Village Circle, Santa Barbara, CA 93108. Laurette Bennett (805) 969-5807. P&A: See text.

A rugged, low-cost keyboard pad made of conductive silicone rubber integrates the functions of a molded plastic key, a tactile spring-back mechanism and an electrical contact in a single molded piece.

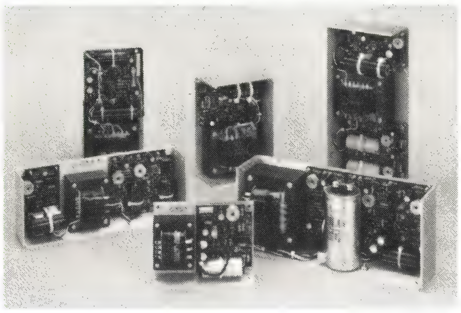
The contact pads on the under side of the keyboard are made of carbon-filled conductive silicone with an unusually low contact resistance. The contacts are rated for 30 mA at 12-V dc, and the contact resistance can be specified from 5 Ω per square cm to as little as 0.35 Ω per square cm. Operating life is greater than 2,000,000 cycles. The key pad diameter, spacing, and key pressure can be specified.

The custom-made keypads are available from Japan from the Shin-Etsu Polymer Co. Delivery is within six to twelve weeks from receipt of customer's drawings; cost varies from $0.02 per contact.

CIRCLE NO. 308

Disk Memory Power Supplies

NUMBER 1 IN D.C. POWER SUPPLIES



Power-One, a leading supplier to the Disk Drive Industry, now offers a complete line of power supplies for FLOPPY DISK and new WINCHESTER FIXED DISK applications.

Call or Write for our New Catalog.

WINCHESTER FIXED DISK

SHUGART - CENTURY - MICROPOLIS are just a few drives powered by this new universal model. Powers (1) Winchester drive plus controller circuitry.

1st Output	2nd Output	3rd Output	Model	Price (1 - 9)
+ 5V @ 9A	− 12V @ .8A	+ 24V @ .5A/4.5A PK	CP384	$120.00

FLOPPY DISK - 5¼" MEDIA

BASF - SHUGART - PERTEC - SIEMENS plus all other popular 5¼" media drives.

1st Output	2nd Output	Model	Price (1 - 9)
+ 5V @ .5A/.7A PK	+ 12V @ .9A/1.8A PK	CP340	$ 44.95
+ 5V @ 2A	+ 12V @ 4A	CP323	$ 74.95

CP323 powers up to (4) drives simultaneously.

FLOPPY DISK - 8" MEDIA

SHUGART - PERSCI - CDC - WANGCO plus many other single and multiple drive applications.

1st Output	2nd Output	3rd Output	Model	Price (1-9)
+ 5V @ 1A	− 5V @ .5A	+ 24V @ 1.5A/1.7A PK	CP205	$ 69.95
+ 5V @ 2.5A	− 5V @ .5A	+ 24V @ 3A/3.4A PK	CP206	$ 91.95
+ 5V @ 3A	− 5V @ .6A	+ 24V @ 5A/6A PK	CP162	$120.00
+ 5V @ 1.7A/2.2A PK	− 5V @ .15A/.2A PK	+ 24V @ .2A/3A PK	CP272A	$ 91.95
+ 5V @ 2A	+ 12V @ .4A	− 12V @ .4A	HTAA-16W	$ 49.95

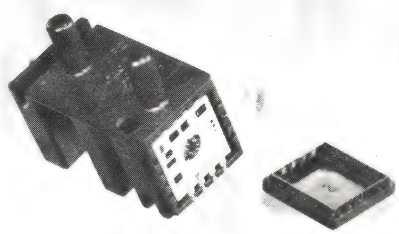
CP272A powers Persci Drives (includes unregulated 7 - 10V @ 1.2A/10A PK). HTAA-16W powers Persci controller.

POWER-ONE D.C. POWER SUPPLIES

Power One Drive • Camarillo, CA 93010 • (805) 484-2806 • TWX 910-336-1297
Eastern Regional Headquarters • (518) 399-9200

CIRCLE NUMBER 113

Pressure transducer stays stable over 0 to 50-C range



Micro Switch, 11 W. Spring St., Freeport, IL 61032. (815) 235-6600. Under $20 (OEM qty).

Addition of a thermistor and laser-trimmed thick-film resistors provide temperature compensation for the Model 126PC pressure transducer. Shift, over a 0 to 50-C range, is typically ±1.5% of full-scale output. Heart of the device is a 0.1-in.^{2} silicon chip. Pressure causes the chip's sensing diaphragm to flex, changing the values of four ion-implanted piezo-resistors in the chip. The sensing resistors are connected as a bridge and operate with constant voltage excitation (16 V dc maximum). Thick-film resistors and the thermistor are external to the chip. The transducer is available in differential and gauge types in three pressure ranges: 0 to 5, 0 to 15 and 0 to 30 lb/in.^{2}. Repeatability and hysteresis for all models is ±0.15% of full-scale output. The chip, resistors and thermistor are enclosed in the 1.5-in. long thermoplastic package.

CIRCLE NO. 458

people who play the computer specify Verbatim

A Victor Borge performance deserves the very best keyboard. And virtuoso performances at the computer keyboard deserve the ultimate in recording quality: **Verbatim cartridges.**

When you're performing cash flow forecasts, inventories and receivable reports on your IBM or NCR office computer (or wrestling technical tasks through a Tektronix system), you want to record every data byte on your system's cartridge memory exactly, so that it will play back **verbatim.**

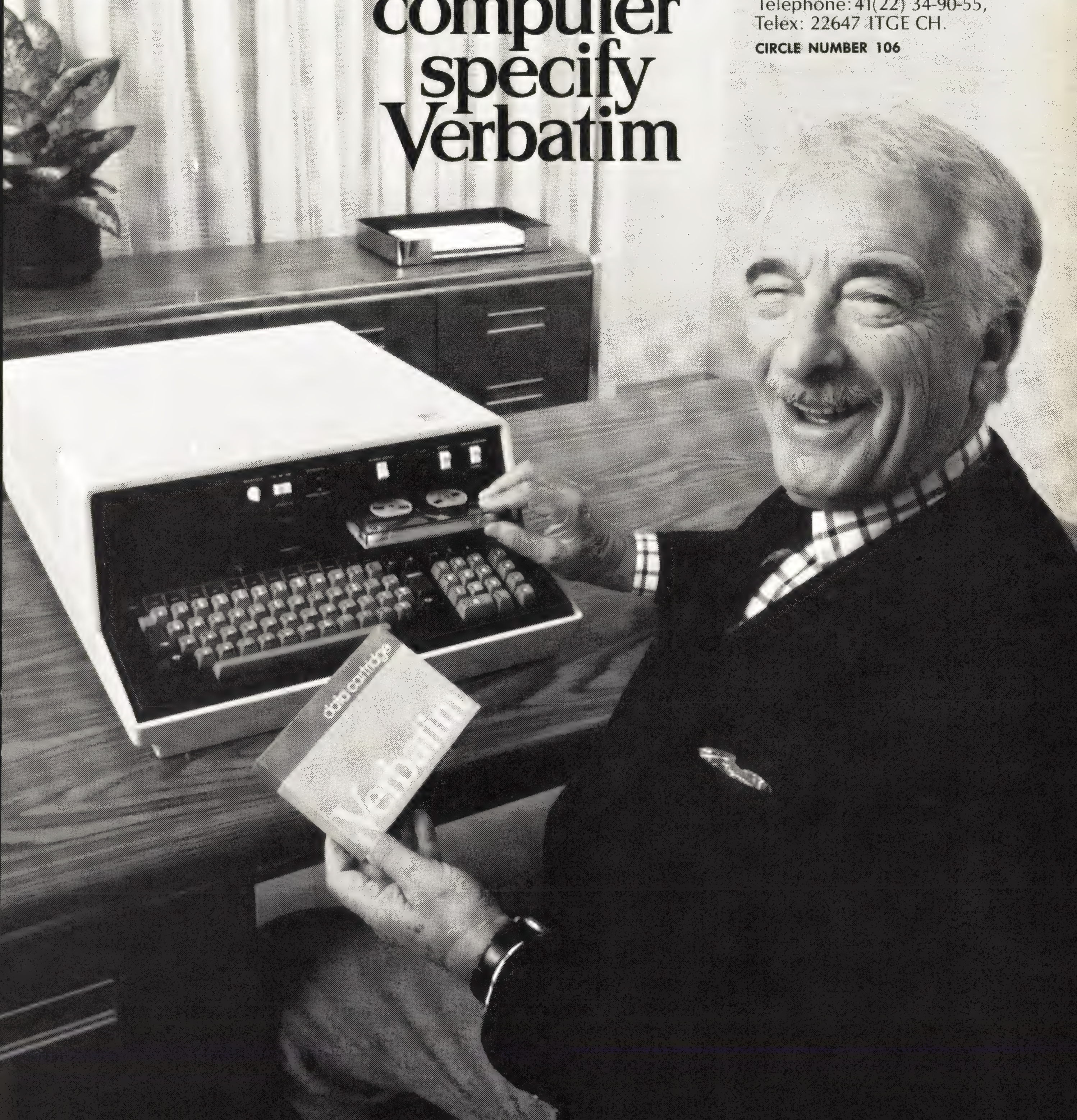
Reason enough to specify Verbatim brand cartridges. At Verbatim, the whole message is quality. We specialize in digital data recording media and have become the industry leader by setting the standards for flawless, dropout-free cartridges, diskettes and data cassettes. Every size, every format, and available everywhere. Order them from your computer supplies dealer.

Simply specify Verbatim. For the name of your nearest Verbatim distributor, call: 800-538-1793. In California call: (408) 737-7771 collect. Verbatim Corporation, 323 Soquel Way, Sunnyvale, CA 94086.

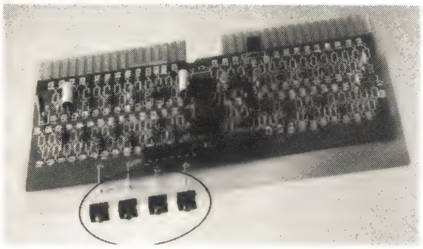
In Europe:

Verbatim S.A.,
Case Postale 296,
1215 Genève 15,
Switzerland,
Telephone: 41(22) 34-90-55,
Telex: 22647 ITGE CH.

CIRCLE NUMBER 106



Long leads simplify LED mounting

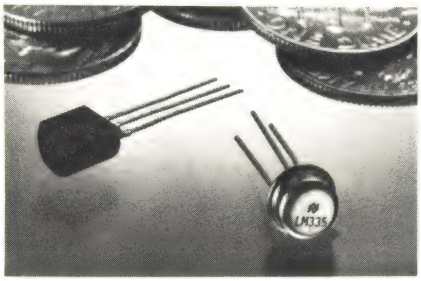


Data Display Products, 303 N. Oak St., Inglewood, CA 90302. (213) 674-5940. $0.32 (1000 qty); stock to 4 wks.

Edge-mounting of LEDs is simplified using PCV125 Series devices. The LEDs mount on the edge of a PC board with straddled leads that are soldered to opposite sides of the board. Standard and super-bright versions are available in red, amber and green and with clear and diffused lenses. Operating voltages are 3.6 to 28 V, with an external resistor required in most cases. The LEDs project 0.305 in. beyond a board edge and mount on 0.245-in. centers. LED diameter is 0.125 in.

CIRCLE NO. 369

IC temperature sensor takes 200-C readings



National Semiconductor, 2900 Semiconductor Dr., Santa Clara, CA 95051. (408) 737-5000. $0.95 (100 qty); stock.

An IC temperature sensor, LM135, measures with better than 1-C accuracy to 200 C. The device acts as a shunt regulator with voltage proportional to temperature. Operating current can range from 0.5 to 5 mA with no change in electrical performance. Overall range is −55 to 200 C. The IC directly reads out temperature in degrees Kelvin. Only two wires are needed to operate the device, minimizing wiring to remote locations. A hermetic TO-46 package is used. A commercial version, LM335, comes in a TO-46 or a TO-92 package.

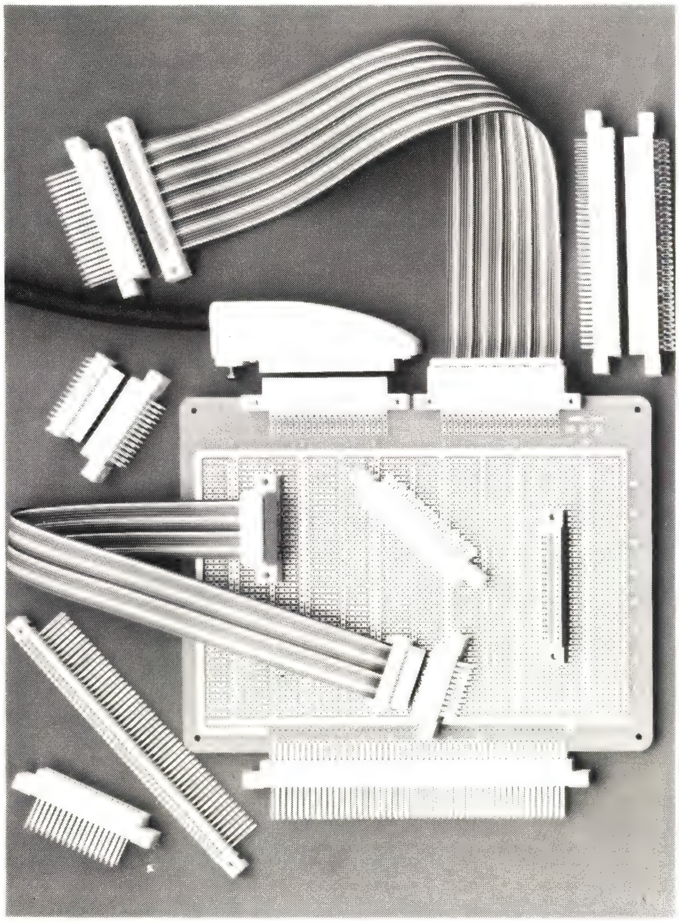
CIRCLE NO. 370

SIP/DIP shunt networks replace wire jumpers

CTS Keene, 3230 Riverside Ave., Paso Robles, CA 93446. (805) 238-0350.

An alternative to individual hand-wired jumper or bus wiring, Series 198 DIP/SIP shunt networks provide error-free matrix programming. Each device consists of a matrix of conductive shunts between opposite and adjacent terminals. Each shunt can be left intact, to complete a connection, or broken, to form an open circuit. The machine-insertable parts are programmed before or after insertion and give a visual indication of programming condition. Pins are on 0.1-in. centers. SIP styles are available with from 2 to 12 pins; DIP styles, 4 to 24 pins. Current rating is 1-A maximum. Dielectric breakdown voltage is 500 V dc minimum between any two electrically isolated terminals. Pins are solder-plated copper alloy. Gold-plated terminals are optional.

CIRCLE NO. 371



Pluggem Connectors

Our new connector line offers versatility never before available to the packaging engineer. With "PLUGGEM" you can interconnect ribbon cable to ribbon cable, ribbon cable to standard .100 center edge card receptacles with various terminal styles. We offer eight sizes of ribbon cable plugs and receptacles. We offer twelve sizes of plugs in right header style and straight plugs with various terminal styles.

In addition to "PLUGGEM" connectors, we manufacture an extensive line of .125 and .156 c/c edge card receptacles with various terminal styles. Call or write for catalog which fully depicts our products:

- PLUGGEM connectors
  100 c/c printed circuit connectors
  125 c/c printed circuit connectors
  156 c/c printed circuit connectors
- Card Racks
- Printed Circuit Boards
- Wire Wrapping Guns
- IC Sockets

QUALITY ...... ECONOMY ...... DELIVERY

KEL-AM
INCORPORATED
P.O. Box 313 Eldon, Mo. 65026
(314) 392-7174 Telex: 42-301

CIRCLE NUMBER 141

Want to see a Nd:YAG that has what you never could buy until now? See CLEOS Booth 106.

It's not only a new laser...it's a new tool!

An industrial laser with reliability, compactness, simplicity that up to now has not been available to you.

It's a whole new generation YAG. A breakthrough. We call it "The Tool," because it is so sturdy, reliable, productive. Just bolt it in place and let it work. Built to take punishment in a factory environment. Maintainable by factory personnel.

Come see it. The new Series 200 industrial Nd:YAG laser. Or write Quantronix Corporation, 225 Engineers Road, Smithtown, N.Y. 11787. Phone 516-273-6900. Telex 96-7782. Or contact our office in Santa Clara, Ca. 408-247-9984.

Quantronix

CIRCLE NUMBER 107

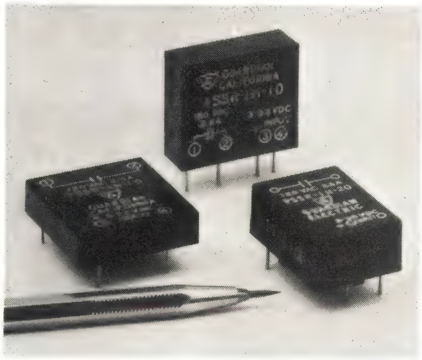
Opto relay replaces reed crosspoint types

Theta-J, 208 W. Cummings Park, Woburn, MA 01801. (617) 935-7600. $3.90 (OCP-2); $4.50 (OCP-2H) (10,000 qty); 4 to 6 wks.

An optically coupled crosspoint relay replaces reed relay types with smaller size and more reliable operation. The four-switch unit is housed in a 14-pin DIP. Each circuit consists of a LED which, when activated, simultaneously latches two independent light-activated SCRs into an "on" condition. The SCRs remain on until the system is reset. Model OCP-2 uses SCRs rated at 60 V dc and will operate from an input of 7 mA. Model OCP-2H carries a 300-V dc rating and requires an input of 15 mA. I/O isolation is 2500 V ac. Transient rejection circuitry is included.

CIRCLE NO. 372

PC-mount SSRs switch up to 2.5 A

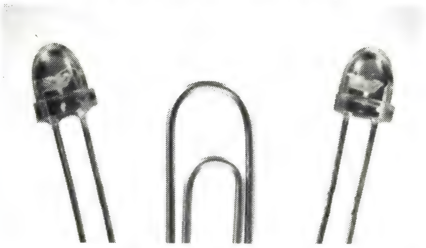


Guardian California, 4030 W. Spencer St., Torrance, CA 90503. (213) 542-8651. Typical $10.72 (100 qty); stock to 16 wks.

PC-mount solid-state relays (SSRs), FSSR, ISSR and PSSR, handle up to 2.5 A "free-air" ac switching. The devices use zero voltage switching for RFI suppression. All are optically-coupled for high isolation between input and output. An internal snubber network protects against false triggering caused by high line transients while switching inductive loads. Both 140 and 280-V ac models are offered. Packaging conforms to the industry-standard, four-pin configuration. All models are fully encapsulated in flame-retardant, nontracking Valox housings.

CIRCLE NO. 373

Low-profile LEDs glow brightly in four colors



Chicago Miniature Lamp Works, 4433 N. Ravenswood Ave., Chicago, IL 60640. (312) 784-1020. Approx. $0.40 (1000 qty); 6 to 8 wks.

A family of short-lens LEDs, X-90B series, offer light-color outputs of red, green yellow or orange with luminous intensities ranging up to 12 mcd. The subminiature, T1-3/4 devices provide half-intensity viewing angles of up to 80° for diffuse-lens styles. Silver-plated leads eliminate most common solderability problems. Operating temperature range is −55 to 100 C.

CIRCLE NO. 374

Turn On Our Dip Switches.
Turn Off Your Switch Problems.

When you're looking for Dip Switches, remember this: every SMK Dip Switch is quality built with important design features that can solve your switching problems and save you money.

Only SMK Dip Switches are designed with a double-sided clip-type wiping contact that provides self-cleaning action for higher reliability and longer life. Every SMK Dip Switch features sealed and oven-cured construction to prevent flux contamination during wave soldering.

And now you have a choice between our standard toggle-lever slide-switches and our new low-profile flush-lever slide-switches – both clearly show red when "on" and white when "off." What's more, each switch position has four positive detents to ensure excellent shock and vibration characteristics.

Both types are available in 1 to 10 switch positions. The flush-lever version can be taped and sealed on the top to protect against contamination during cleaning. Plastic caps are also available to protect pre-programmed switch settings. Available in SPST configurations, SMK's slide-type Dip Switches are rated at 24V DC at 300mA switching, resistive load, and will operate from −20°C to +87°C.

Want to know more? For any kind of switch – Push Buttons, Dip's, Toggles, Slides, Rockers, etc. – contact SMK, the switchmaker.

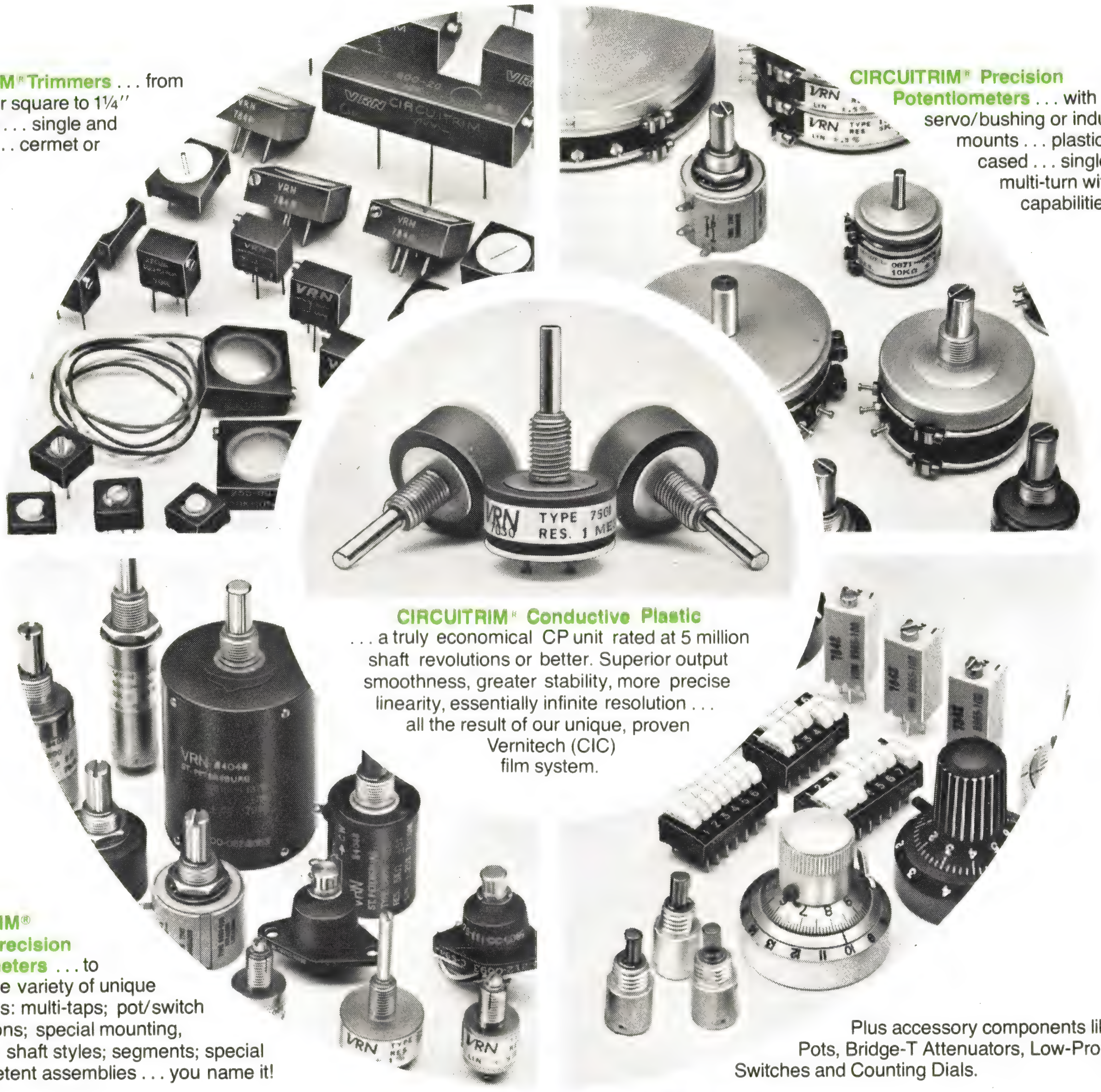
SMK

SMK Electronics Corporation of America
113 E. Savarona Way, Carson, Ca. 90746 · Phone (213) 770-8915

CIRCLE NUMBER 114

VRN Trimmers and Precision Potentiometers

. . . are designed to meet the exacting needs of industrial and military specifications. Whatever your need . . .



CIRCUITRIM® Trimmers . . . from ¼″ round or square to 1¼″ rectangular . . . single and multi-turn . . . cermet or wirewound.

CIRCUITRIM® Precision Potentiometers . . . with servo/bushing or industrial mounts . . . plastic or metal cased . . . single and multi-turn with ganging capabilities to 25.

CIRCUITRIM® Conductive Plastic . . . a truly economical CP unit rated at 5 million shaft revolutions or better. Superior output smoothness, greater stability, more precise linearity, essentially infinite resolution . . . all the result of our unique, proven Vernitech (CIC) film system.

CIRCUITRIM® Custom Precision Potentiometers . . . to meet a wide variety of unique applications: multi-taps; pot/switch combinations; special mounting, housing or shaft styles; segments; special torques; detent assemblies . . . you name it!

Plus accessory components like Squelch Pots, Bridge-T Attenuators, Low-Profile Dip Switches and Counting Dials.

. . . VRN has it for fast, off-the-shelf delivery.

VRN trimmers and precision potentiometers are available in the widest selection of sizes and mounting configurations possible.

More importantly, each is 100% electrically tested to rigid Quality Control standards before shipment . . . your assurance that VRN products will meet the most critical environmental specifications.

For immediate delivery, contact your nearest VRN Distributor, or write today for your copy of our comprehensive catalog.

VRN 100% tested
INTERNATIONAL
a Division of Vernitron Corp.

Manufacturers of precision potentiometers, trimmers and dip switches

P. O. Box 44000 / St. Petersburg, FL 33743 / Tel: 813-347-2181
TWX: 810-863-0357 TELEX: 523417

CIRCLE NUMBER 109

5-W zeners protect against transients

Motorola Semiconductor Products, P.O. Box 20912, Phoenix, AZ 85036. (602) 244-6900. $1.14 to $2.25 (100 qty); stock.

An axial-lead, plastic-packaged zener series, 1N6267 through 1N6303, protects voltage-sensitive components against high-energy transients. The devices are rated for 1500-W peak power dissipation for a 1-ms pulse. Dissipation is 5 W under steady-state conditions. Forward surge is rated at 200 A for an 8-ms pulse. Maximum clamping voltage is specified at rated reverse surge current. Response time is good, typically less than 1 ns. Devices are offered over the standard zener diode voltage range of 6.8 to 200 V, 5% and 10% tolerance.

CIRCLE NO. 375

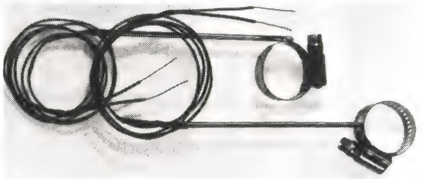
Proximity sensors detect objects as close as 1 mm

Omron Electronics, 650 Woodfield St., Schaumburg, IL 60195. (312) 843-7900.

Forty different types of cylindrical proximity switches, TL-X series, sense objects as close as 1 mm. The devices come as small as 8 mm for dc service and in shielded and non-shielded types in sizes of 12, 18 and 30 mm for ac and dc switching. All models accept a wide range of input voltages, either 10 to 40 V dc or 45 to 260 V ac. Water-tight housings and an ambient temperature range of −45 to +85 C protect the devices in industrial environments. Current consumption is low—only 2 mA maximum for ac units and 10 mA maximum for dc types. For ac versions, a high dielectric strength, 4000 V ac, eliminates need for a ground wire. Most types include a red LED to facilitate operation monitoring and adjustment. DC sensors come with short-circuit, surge and reverse-polarity protection.

CIRCLE NO. 376

Clamp thermocouples install in a snap



Nanmac, 9-11 Mayhew St., Framingham Centre, MA 01701. (617) 872-4811. $20; stock.

Hose clamp thermocouples easily install on pipelines with just a screwdriver. Twenty different sizes are available for pipes of from 7/32 to 6-3/4 in. outside diameter. Four standard thermocouple calibrations are offered. Temperature range is up to 700 F for the 5-ft, fiberglass-insulated leads and 1000 F for the stainless steel clamp.

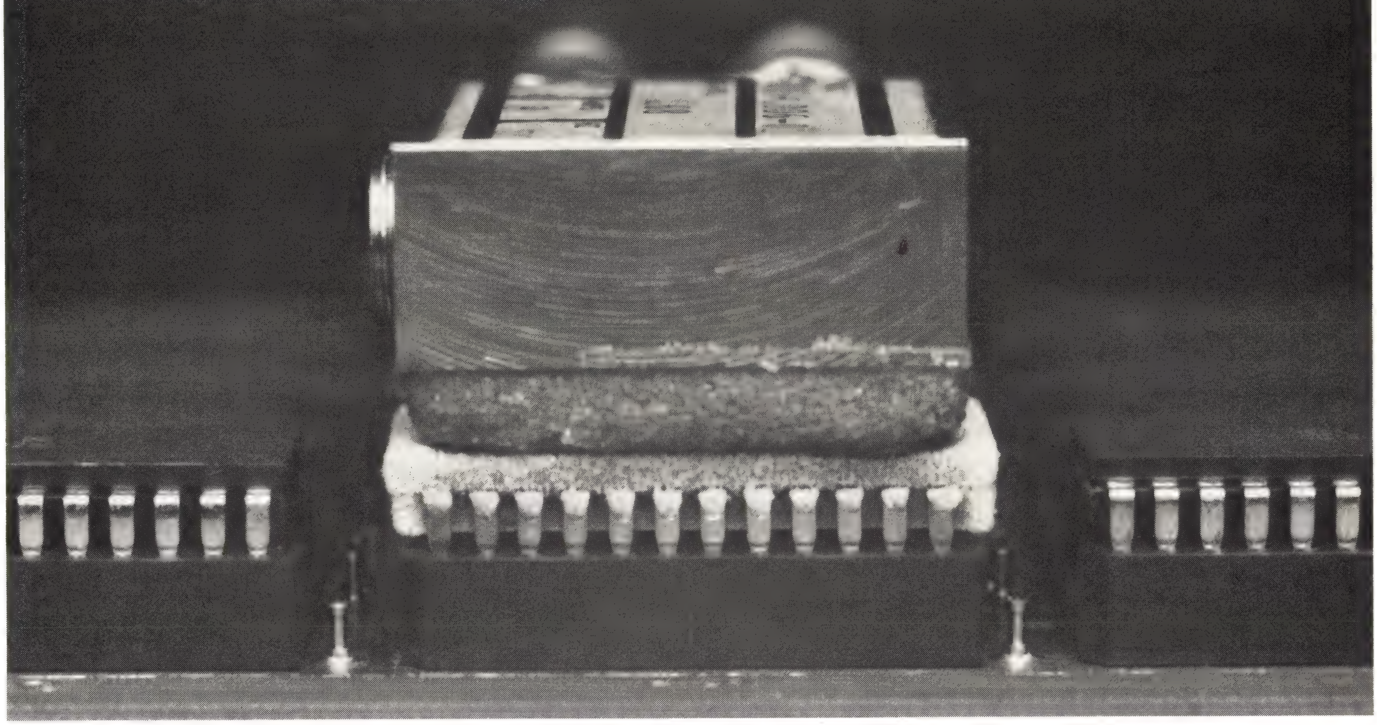
CIRCLE NO. 377

Knobs
for Anything
you can Think of

Weird.
Wonderful.
Or very down-to-earth.
Custom or off-the-shelf.
EHC's total "in-house" operation
makes the difference.
In quality.
In shortest lead time.
In best prices.
Try us.

Electronic Hardware Corp.
320 Broad Hollow Road, Farmingdale, New York 11735. 516-752-1950.
CIRCLE NUMBER 115

Many Electronic Design Problems Could Benefit From a Little Cool Thinking



Herewith are a few modest examples:

Circuit miniaturization:
Often, power dissipation is the limiting parameter in electronic circuit miniaturization. *Solution:* Actively pump the heat out of the circuit package.

Hot environments:
Circuits operating in hot environments overheat and malfunction. *Solution:* Refrigerate these circuits. Cool them to acceptable operating levels.

Noisy, drifting amplifiers:
Amplifiers are noisy at high temperatures and, in some, critical parameters drift, excessively, with temperature change. *Solution:* Regulate amplifier operating temperature to a fixed, cool level.

But design philosophy is not all we have to offer. We have the hardware too. They're called thermoelectric modules. Sandwiched between your circuit package and a suitable heat sink, the thermoelectric module can heat or cool your electronics package and keep it at any preset operating temperature in the range of ambient ±70°C.

Thermoelectric modules are available in a wide variety of shapes and sizes, with or without (air or water) heat sinks, power supplies, or temperature controllers. We also maintain a custom design laboratory where customers bring challenging cooling and temperature regulatory problems everyday.

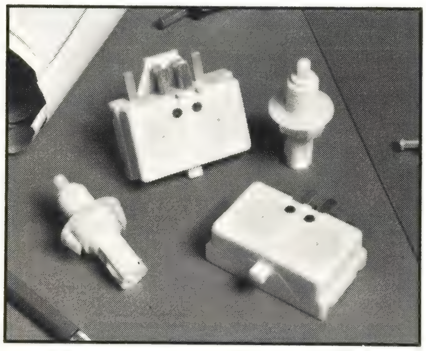
Let us tell you more about thermoelectric modules and their applications. Call or write for our *new* catalog 300: thermoelectrics.

CAMBRIDGE THERMIONIC CORPORATION
CAMBION®
445 CONCORD AVENUE, CAMBRIDGE, MASSACHUSETTS 02238
Telephone (617) 491-5400 TWX (710) 320-6399
TELEX 92-1480 Cable CAMBION

West coast office: Cambridge Thermionic Corporation, 2733 Pacific Coast Highway, Suite 308, Torrence, Cal. 90505 Tel. (213) 326-7822, 7823, 7824

CIRCLE NUMBER 111

Mineral-reinforced Valox resists heat and impact, and saves money



General Electric Co., Plastics Division, One Plastics Ave., Pittsfield, MA 01201. Len Cesario (413) 494-5430.

The latest additions to the 700 series of mineral-reinforced Valox materials cost less than other reinforced thermoplastic polyesters, without sacrificing dimensional stability and heat resistance. The 746, 760 and 761 series from General Electric can replace metal in applications requiring high impact and dielectric strength.

The dielectric strength of the new Valox series is 450 V/mil, which makes them useful for connector or switch housings, automotive applications, electronic instrument enclosures and other insulating applications. The Valox 760 resin carries a UL V-O rating; the Valox 761 resin has a UL V-2 rating; and the 745 and 746 Valox plastics have UL HB listings.

Unlike zinc, aluminum or other molding materials, the Valox resins can be processed with little trimming and deburring. Colors may be molded in, eliminating both painting, finishing, and other operations.

CIRCLE NO. 309

Thick-film pastes form hermetic seals

Thick Film Systems, 324 Palm Ave., Santa Barbara, CA 93101. (805) 963-7757. $0.68/g (OEM qty); stock.

Four screen-printable pastes for multilayer thick-film use produce hermetic seals for long-term reliability in the presence of moisture, silver-bearing conductors and hostile environments. Members of the ISO-OHM line of dielectric formulas, the pastes are compatible with a variety of metallizations, including golds, platinum-golds and silver compositions. Fired layers offer high insulation resistance, high breakdown voltage and a low dielectric constant. Partilok, an organic screening vehicle, eliminates particle settling and permits printing on high-speed screen printing machines. Formulas 1005RCA and 1005RCT retain their color after firing at 850 C. Formula 1009TCR closely matches the thermal expansion of 96% alumina to overcome substrate warpage. Formula 1001TCU is a clear, vitreous substrate glaze and ceramic seal glass. The pastes come in plastic cartridges for automatic feeding.

CIRCLE NO. 378

Fused quartz fibers form chemically inert paper

Atomergic Chemetals, 100 Fairchild Ave., Plainview, NY 11803. (516) 822-8800.

Papsil, a paper-like material formed from fused quartz fibers, tolerates long periods of exposure to temperatures of 1000 C without alteration or loss of weight. The material is resistant to most chemicals and acids and is insoluble in water.

CIRCLE NO. 379

Fire retardant comes in finer particle size

Solem Industries, 3400 Oakcliff Rd., Atlanta, GA 30340. (404) 458-9107.

A fine particle-size alumina trihydrate, SB-832, adds its fire-retardant capabilities to vinyls, wire and cable insulation, polyethylene, ABS, epoxy and other materials. The substance is especially suited to thin-film and other applications requiring very fine particle distribution. Maximum particle size is 6 microns, with median particle size, 1.5 microns.

CIRCLE NO. 380

Nylon resin reduces mold cycle times

Monsanto Plastics & Resins, 800 N. Lindbergh Blvd., St. Louis, MO 63166. (314) 694-1000. $1.34/lb (OEM qty).

Vydyne 21SL, a grade of nylon 66, offers good mold release qualities. This permits part ejection from molds at higher part temperatures, thus allowing shorter molding cycle times. Part release from difficult molds is easier, eliminating part hang-up or use of mold release sprays. The resin forms a wide variety of electrical and electronic items.

CIRCLE NO. 381

Plastic modifiers give inherent conductivity

Transmet, 1375 Perry St., Columbus, OH 43201. (614) 424-6161. Approx. $2.00/lb; stock to 1 wk.

Series 100 conductive modifiers mix with a variety of plastics to yield a final product with high electrical and thermal conductivity. Supplied in flake or fiber form, the aluminum alloy particles are formed from a molten bath to eliminate variations inherent in machining techniques. Modified plastics can be molded into shielded boxes, large computer housings, conductive conduit and cable sheathing. Because shielding and conducting properties are inherent in the polymer system, shielded enclosures have no brittle coating which can flake during post-molding operations. No special preparations are required for painting modified plastics. Heat conduction properties of modified plastics permit their use as integral heat sinks.

CIRCLE NO. 382

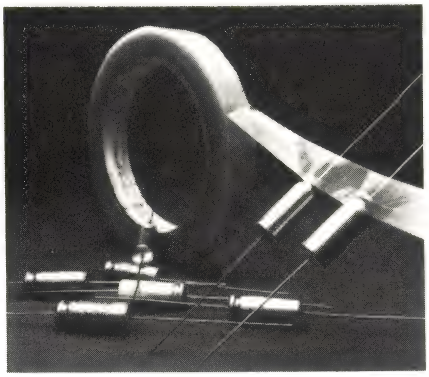
Platinum-gold conductor offers good adhesion

Electro Materials, 605 Center Ave., Mamoroneck, NY10543. (914) 698-8434.

A platinum-gold conductor. EMCA 7170, provides high adhesion with good solder leaching characteristics. A 100 × 100-mil pad will sustain a tensil pull in excess of 16 lb and a peel adhesion in excess of 10 lb. Solder wetting by eutectic solder takes less than 5 s at 200 C. The conductor contains 85% inorganic solids. Resistivity is 25 to 35 mΩ/sq/mil. Viscosity is 180,000. Optimum firing range is between 850 to 925 C for 10 minutes.

CIRCLE NO. 383

Shrinkable tape insulates and identifies capacitors



3M Industrial Electrical Products, P.O. Box 33600, 3M Center, St. Paul, MN 55133. (612) 733-1110.

A heat-shrinkable polyester film tape, Scotch #1320, insulates and identifies tantalum and aluminum tubular electrolytic capacitors. The 1-mil tape is coated with an acrylic, pressure-sensitive adhesive. The adhesive can be printed on, preventing inadvertent identification removal during cleaning. The tape has good flagging resistance and resistance to shrink-back on capacitors aged at 125 C. Scotch #1320 comes in 72-yd rolls with a width tolerance of ±1/64 in. Tighter tolerances are available. Dielectric strength is 5000 V; insulation resistance, 1 × 10^6 MΩ; adhesion to steel, 30 oz-in. Lengthwise shrinkage is 18% at 150 C.

CIRCLE NO. 384

Aluminum-coated fibers conduct heat/electricity

Hexcel Structual Products, 11711 Dublin Blvd., Dublin CA 94566. (415) 828-4200.

Thorstrand, a fabric of aluminum-coated fibers, lends its conductive properties to a wide variety of applications including dissipation of static electricity, EMI shielding, lightning-strike protection and for fabrication of antenna ground planes. Use of Thorstrand eliminates additional fabrication processes, such as coating with conductive paint or application of metallic screens. A range of epoxy, polyester and polyimide resin systems are available in combination with Thorstrand aluminized-glass reinforcements. The material is woven with Metafil G, fibers consisting of an E-glass filament with a chemically-bonded, continuous coating of pure aluminum.

CIRCLE NO. 385

for best results... first convert to IMC

IMCube VANEAXIAL FAN

This easy to install, one inch cube powerhouse does wonders for spot cooling critical components. It's called the IMCube and delivers air at 11,000 times its own volume each minute. Also available in one inch diameter cylinder configuration. Literature on request! For further information please call E. V. Lauria, Sales Manager at 516/334-7070 or write:

400 HZ

IMC MAGNETICS CORP.
EASTERN DIVISION
570 MAIN STREET, WESTBURY, NEW YORK 11590

CIRCLE NUMBER 118

Don't be embarrassed if the product you're using doesn't compare to this . .

Lots don't. The PKW-5000, an EPROM Programmer and Z80 Computer, is in a class by itself. With powerful capability, ample functions and excellent reliability, this extremely compact unit is, nonetheless, expandable. It can be used as an EPROM Programmer as well as a simulator and as a debugger. And don't be embarrassed if you thought it costs more than it does.

For a non-embarrassing comparison contact us for complete information, price and delivery.

WES-CON PRODUCTS, INC.
525 University Ave., Suite 705, Palo Alto, CA 94301, Telephone (415) 327-4051, TELEX 345549

CIRCLE NUMBER 119

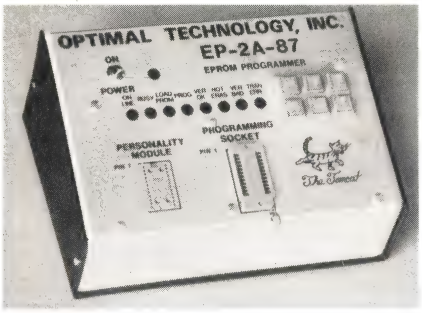
Low-speed tape transports back-up disk storage

Control Data, P.O. Box O, Minneapolis, MN 55440. (612) 853-3165. $2700.

A family of tension-arm magnetic tape transports, CDC 92140 series, performs a variety of data storage jobs including disk back-up, serial data collection and data exchange between computer systems. The single-capstan units operate at speeds ranging from 18.75 to 45 in./s and read and write standard 9-track data in densities of 800 and 1600 bits/in. using NRZI and PE modes, respectively. All transports use microprocessor-based control logic. Micro-diagnostic aids simplify maintenance. An optional embedded formatter offers dual recording modes (PE/NRZI) and is contained on a single PC board. Daisy-chain connection is available for up to four transports.

CIRCLE NO. 386

Programmer goes on-line with RS232/20-mA ports



Optimal Technology, Blue Wood 127, Earlysville, VA 22936. (804) 973-5482. P&A: See text.

Remote EPROM programming is possible through an RS232 or 20-mA interface on the Model EP-2A-87 programmer. In its on-line mode, the unit offers 2-k or 4-k buffer memory. Standard baud rates are 1200 and 110, DIP-switch selectable. In an off-line mode, a keyboard allows programming, verification, loading and checking of devices. An audio tone prompts users during a programming sequence. Built-in self-test includes provisions for checking buffer memory. The programmer is $600 with 4-k of buffer. Personality modules are from $16 to $35 each for programming 2704, 2708, 2716, 2732, TMS 2708, TMS 2716, TMS 2516, TMS 2532 and MCM68764 EPROMs. Power requirement is 115 V ac at 50/60 Hz.

CIRCLE NO. 387

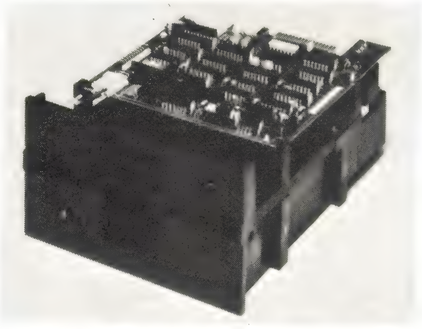
Serial printer increases 3270 System performance

Decision Data Computer, 100 Witmer Rd., Horsham, PA 19044. (215) 674-3300. $3975; 8 to 9 wks.

A serial printer, Model 6541, directly replaces IBM 3284 andd 3286 printers in the 3270 Information Display System. The 6541 prints bidirectionally at 150 char/s along a print line of 132 columns. Characters, from a set of 64, are formed by a 9 × 7 dot matrix. The unit is offered for sale or for monthly rental.

CIRCLE NO. 388

Dc motors power 5-1/4-in. floppy disk drives



TEAC, 7733 Telegraph Rd., Montebello, CA 90640. (213) 726-9035. $298 (FD-50A); $410 (FD-50C).

Two models of 5-1/4-in. floppy disk drives use dc brushless motors. The motors, which run continuously, provide fast data access. Model FD-50A is a single-track unit for 40 tracks per disk. FD-50C is a double-track version with 77 tracks per disk.

CIRCLE NO. 389

Bisync plotting controller emulates terminal

Versatec, 2805 Bowers Ave., Santa Clara, CA 95051. (408) 988-2800. $6500; 8 to 9 wks.

A bisync plotting controller, Model 440-20, provides remote electrostatic plotting and printing for Versatec printer/plotters, while emulating an IBM 3780 data communication terminal. A host computer, using Versaplot software, processes and compresses input data and transmits it over data communications lines in raster format. The controller decompresses raster data and directs plotting and printing. The unit carries data-link trace facilities and self-test diagnostics. Synchronous RS232C data is input at rates from 2400 to 19,000 bits/s.

CIRCLE NO. 390

Digitizer captures data for storage and analysis

Bancomm, 1121 San Antonio Rd., Palo Alto, CA 94303. (415) 969-7555. $25,000; 17 wks.

A wideband digitizer, WBD-210, captures, demodulates and analyzes wideband signal data. The unit interfaces with DEC PDP-11 or similar minicomputer system via the Unibus. All system functions are under software control from the host computer and can be altered "on the fly." Data cycling through memory can be software demodulated or continuously analyzed for feature recognition. Once recognized, data can be held for further analysis, modification or transmission to external equipment. High-speed a/d converters permit dual-channel 10-MHz, 8-bit sampling or single-channel 20-MHz sampling. Memory capacity is 32 kwords (16-bit) partitioned into two 32-k high and low-byte sections. Memory appears to the PDP-11 as standard 32-k RAM core. The unit is housed in a rack-mountable DEC H909-BA enclosure.

CIRCLE NO. 391

Disk system boosts EXORciser capacity

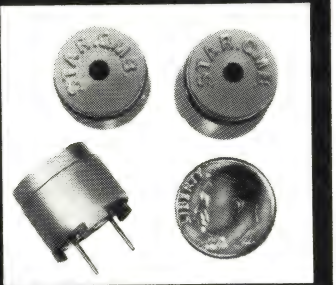
Software Dynamics, 2111 W. Cresent Ave., Suite G, Anaheim, CA 92801. (714) 635-4760. $6995; 4 wks.

Up to 10 Mbytes of hard disk storage can be added to Motorola 6800 EXORciser systems using the Storage Demon memory system. The Winchester drive unit comes with disk controller and SDOS disk operating system. The Storage Demon provides a capacity of 19,000, 512-byte sectors. A sealed media allows trouble-free operation under most environmental conditions. The unit is upward and downward compatible to both the EXORciser I and II. SDOS, an interrupt-driven disk operating system, features keyboard type-ahead, automatic disk read-ahead and disk sector pooling and dynamic files with random access to the byte. SDOS also supports EXORdisk I, II or III, allowing use of existing floppy disk drives for additional or backup storage.

CIRCLE NO. 392

NEW from STAR MICRONICS:

Series QMB miniature audio transducers replace costly speakers & piezo ceramic crystals!



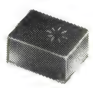
STAR SERIES QMB transducers are ideal for telecommunications equipment, automotive and aircraft systems, medical instruments and other products. Three models—rated at 1.5, 6 and 12 volts DC—produce a continuous tone or interrupted "beeper" sound over any audible frequency range. Current drain is low: only 15 mA for the 1.5 volt model, 40 mA at 6 and 12 volts with an externally-applied 2,048 Hz half-duty cycle. Pins fit standard DIP sockets or may be wave-soldered directly to PC boards without additional wiring. Write today for complete engineering data and prices.

STAR offers you a complete line of precision- engineered, solid state audio indicators... U.S. Patent Nos. 3,974,499; 3,887,914 and 4,065,733

CMB miniature solid-state buzzers

SDB cost effective smoke detector horn

SMB similar to CMB with wires


MMB: one of the tiniest available

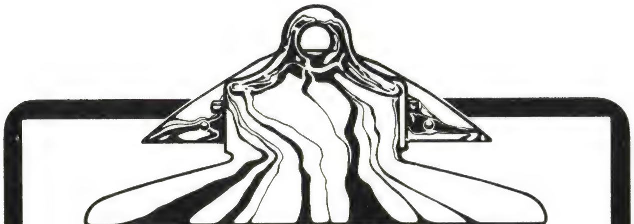
star micronics, inc

SUBSIDIARY OF STAR MFG. CO., LTD.
PAN AM BUILDING, Suite 2308
200 Park Ave., New York, N.Y. 10017
• 212/986-6770 • TWX: 710-581-4082

©1979 Star Micronics, Inc. 79-1

IN CANADA CALL: LENBROOK INDUSTRIES, LTD. • 416/438-4610

CIRCLE NUMBER 117



The Memory Refresher...

That's GOLD BOOK

When you spec hundreds of products annually, and have to find second or third sources for each, it gets tough to always remember who makes what. That's where ELECTRONIC DESIGN's GOLD BOOK comes in. With over 10,000 companies (both US and non-US) listed and their products identified under over 5500 Product Headings, you won't miss a one. Remember, GOLD BOOK is the World's Most Complete Electronics Directory.

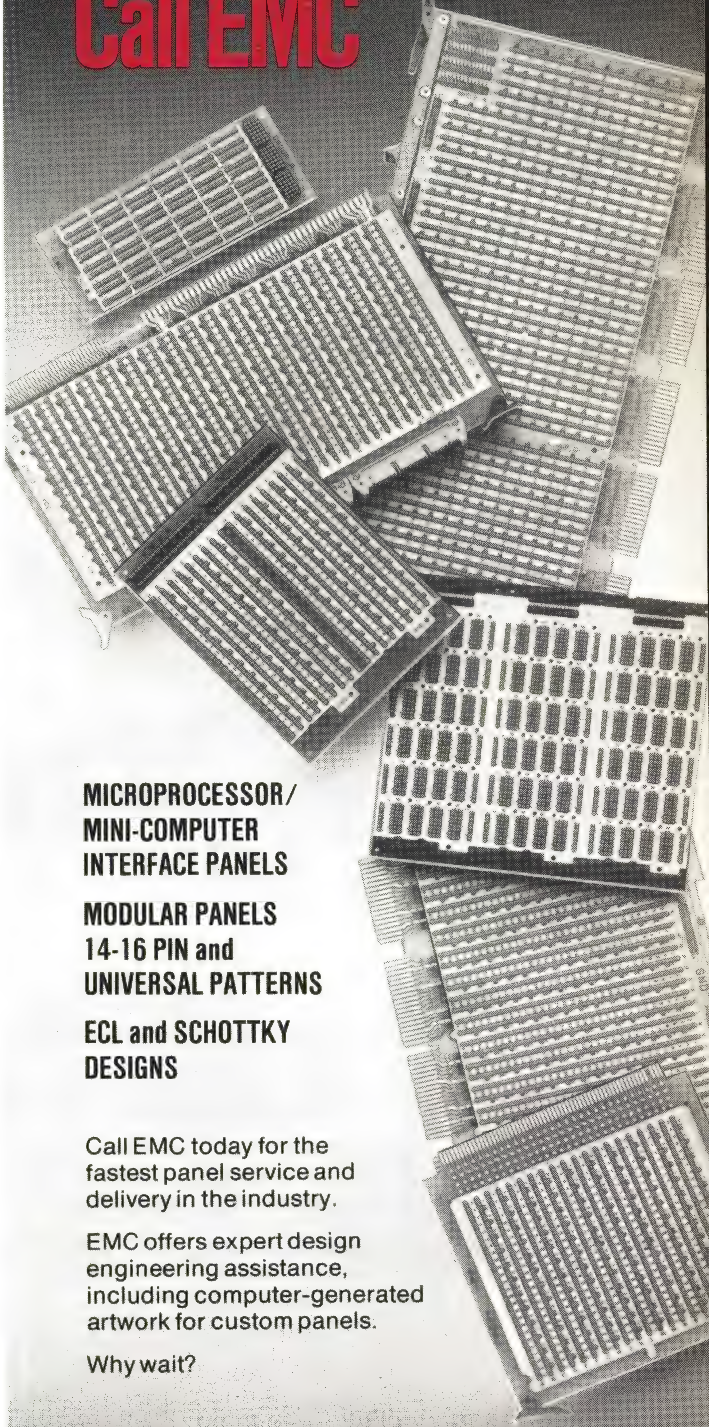
"Over 108,000 Distributed Worldwide."

Electronic Design's
GOLD BOOK
THE WORLD'S MOST COMPLETE ELECTRONICS DIRECTORY

Hayden Publishing Company, Inc.
50 Essex St., Rochelle Park, NJ 07662 • 201-843-0550

Fast Panels

Call EMC



MICROPROCESSOR/ MINI-COMPUTER INTERFACE PANELS

MODULAR PANELS 14-16 PIN and UNIVERSAL PATTERNS

ECL and SCHOTTKY DESIGNS

Call EMC today for the fastest panel service and delivery in the industry.

EMC offers expert design engineering assistance, including computer-generated artwork for custom panels.

Why wait?

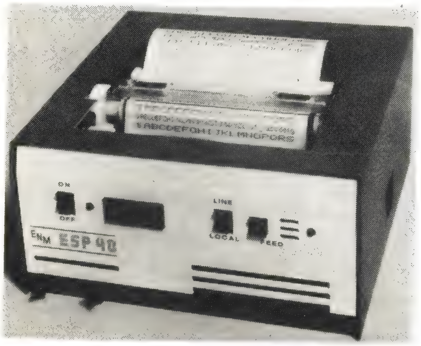
EMC®

Interconnection Specialists

ELECTRONIC MOLDING CORP. 96 Mill Street,
Woonsocket, RI 02895 / (401) 769-3800 / TWX710-387-1350

CIRCLE NUMBER 116

Matrix printer goes mobile on 12-V power

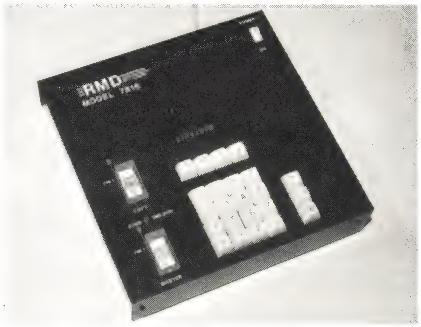


Rank Numbering Machines, 411 E. Jarvis Ave., Des Plaines, IL 60018. (312) 297-2124.

An electrosensitive matrix printer, ESP40, operates from a 12-V supply, making it suitable for mobile applications. The unit produces 40-character alphanumerics on aluminum-coated paper. Other printing fonts are available. A self-test option is offered.

CIRCLE NO. 393

Programmer accepts 2708 and 2716 memories

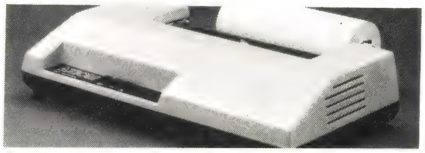


RMD, P.O. Box 206, Bristol, PA 19007. (215) 949-2588. $895; 6 to 8 wks.

An EPROM programmer, Model 7816, avoids the cost of a universal programmer for 2708 and TMS 2716 memory users. Editing features allow the user to read, correct and verify data before comitting it to PROM. Operation is based on 2 kbytes of editing RAM. Data may be entered into RAM from a keyboard, master socket or serial interface. Master and copy sockets are protected. Model 7816 is self-contained and does not require a personality module or host computer.

CIRCLE NO. 394

Low-profile printer generates one line/s

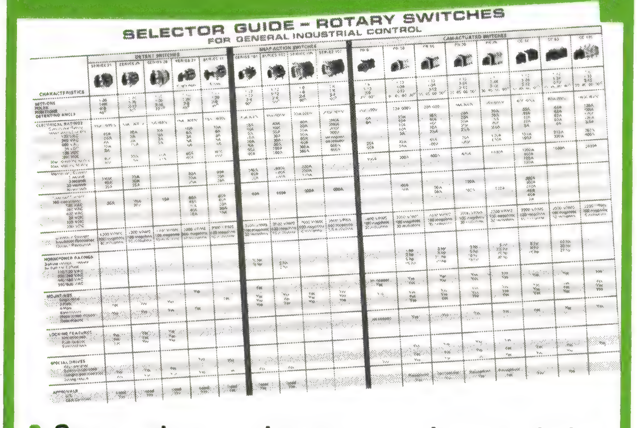


Axiom, 5932 San Fernando Rd., Glendale, CA 91202. (213) 245-9244. $695 (IMP-1); $795 (IMP-2); stock to 9 wks.

Low-profile IMP Series impact printers stand only 3-1/2 in. high and turn out copy with a throughput of one line per second. From 80 to 132 columns can be printed. IMP-1, with a friction feed, produces three copies on plain 8-1/2 in. wide paper. IMP-2 has both friction and tractor feed, with tractors adjustable from 2-1/2 to 9-1/2 in. A 7 × 7 dot matrix handles a standard 96 ASCII character set. Under software control, IMP-2 produces graphics. Special character sets are optional. A standard 512 character buffer is optionally expandable to 2-k. Standard inputs include Centronics parallel, RS232C and 20 mA serial to 1200 baud (9600 baud optional).

CIRCLE NO. 395

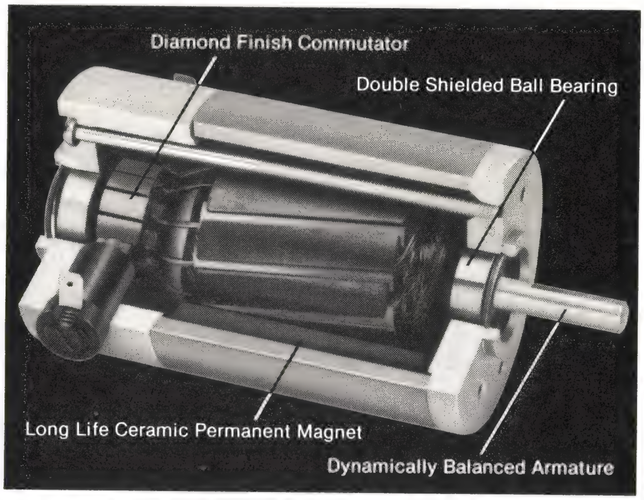
FREE...WALL CHART POWER ROTARY SWITCHES


SELECTOR GUIDE – ROTARY SWITCHES
FOR GENERAL INDUSTRIAL CONTROL

- Snap-action . . . detent . . . and cam switches
- Ratings from 10A-240V to 200A-600V
- Up to 75 poles
- Many standard & custom options
- Fast deliveries

ELECTRO SWITCH
Weymouth, Massachusetts 02188
Telephone: 617/335/5200 • TWX: 710/388/0377

CIRCLE NUMBER 120


Diamond Finish Commutator
Double Shielded Ball Bearing
Long Life Ceramic Permanent Magnet
Dynamically Balanced Armature

You Don't Have To Order 5,000 Motors to Get Our Attention

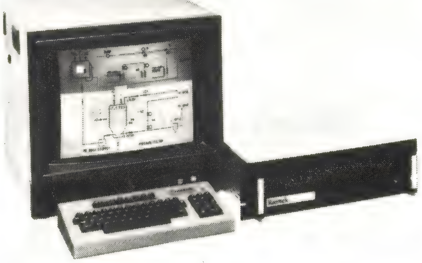
We customize our P.M. DC motors and motor generators to meet your specifications — even on orders of 100 or less. And, it doesn't cost you a fortune. Or even a long wait. We ship most small quantity motor orders in 5-10 working days.

Designed for precision instrument drive applications, each motor is individually crafted. Is run in for 12-48 hours. And then tested. Long life, low ripple. DC motors to 1/10 H.P. from Dynetic Systems.

DYNETIC SYSTEMS
Dynetic Systems Corporation
19128 Industrial Boulevard
Elk River, MN 55330

CIRCLE NUMBER 121

Graphics system adds color combinations



Ramtek, 2211 Lawson Lane, Santa Clara, CA 95050. (408) 988-2211. $4275; 8 to 9 wks.

A color video display controller, FS 2500, enhances video graphics with 64 foreground/background color combinations. The programmable display offers 254 characters. Standard colors are blue, green, red, yellow, magenta, cyan, black and white. Characters include 64 ASCII upper-case and 31 lower-case characters in a 10 × 8 matrix and a 12 × 9 field. Semigraphics character sets include 2 × 3 element symbols; 64 in a 12 × 9 matrix and 31 to replace the lower-case character set. The system displays 32 lines of 80 characters at a 60-Hz refresh rate. Three blink rates are standard. A 48-line format is available. The system consists of a rack-mounted display generator unit, an optional free-standing keyboard and optional 13 or 19-in. color monitors.

CIRCLE NO. 396

CRT terminal displays in eight colors

Integrated Data Systems, 121-B N. Plains Industrial Rd., Wallingford, CT 06492. (203) 265-7841. $3295 (small qty); 4 to 8 wks.

A color display CRT terminal, CD-400, provides alphanumerics and graphics in eight colors. Data format is 24 lines of 80 characters, with two full pages of scrolling display memory. Each character is definable with one of the eight foreground and background colors with inverse or blink attributes. A standard 128 ASCII character set is produced with optional programmed symbols for line ruling, math characters, ISA characters and large characters. Both incremental and absolute cursor positioning are standard. Interface is asynchronous RS232C or 20-mA current loop. Data rates are selectable from 75 to 9600 bits/s at full or half duplex.

CIRCLE NO. 397

OEM mini disk drive retains 160 Mbytes

Control Data, P.O. Box 0, Minneapolis, MN 55440. (612) 853-7600. $5785 (OEM qty); 4 wks.

A double-density mini-module disk drive, CDC 9730-160, extends up to 160 Mbytes of storage to the OEM. The sealed module contains a disk spindle, recording media, rotary actuator and data recording heads. The recording environment is protected from external contaminants. Drive format and interface are compatible with the SMD 9760 series of removable media drives.

CIRCLE NO. 398

Bar code wand gathers data for your system

Hewlett-Packard, 1507 Page Mill Rd., Palo Alto, CA 94304. (415) 856-1501. $99.50; stock.

A digital bar-code wand, HEDS-3000, supplies fast data entry into an OEM system. The device scans a bar code and puts out a logic-level, pulse-width representation of the bars and spaces. An alternative to keyboard and other forms of data entry, the wand offers the added advantages of speed, accuracy and the use of an inexpensive data media—paper. Heart of the wand is a precision optical sensor that can read all common formats printed with a minimum bar width of 0.3 mm (0.012 in.). Light from a 700-nm LED projects through one half of a bifurcated plastic lens. The other lens half focuses reflected light onto a silicon photodetector. An on-board transistor provides added gain. Signal-conditioning circuitry includes an analog amplifier, a digitizing circuit and an output transistor. The replaceable, low-friction tip is abrasion resistant. The wand measures 5.2-in. long and is supplied in a number of colors and with custom labeling.

CIRCLE NO. 399

7-Digit
Portable Hz Meter!!
One Hz to 60 MHz or 512 MHz

FM-7 Frequency Meter $215.00
SC-5 Prescaler $107.80

- Small size.
- Great price.
- Excellent accuracy.
- Tremendously rugged.
- Batteries & charger unit included.

NLS products are available from Nationwide Electronic Distributors. Send for our brochure today!

NLS
Non-Linear Systems, Inc.
Originator of the digital voltmeter.
Box N, Del Mar, California 92014
Telephone (714) 755-1134 TWX 910-322-1132

CIRCLE NUMBER 122

CURRENT MONITORS

With our monitor and your oscilloscope, read fast pulsed currents (nsec to millisec) of any conductor. Prices range from $70 for standard, in-stock models. Sensitivities from 1 V/A to .01 V/A; no physical connections required; readings without ground loops; BNC standard; specials upon request.

For further information write or call: Ion Physics Company, P.O. Box 416, Burlington, Mass. 01803. Tel. 617-272-2800.

IPC ION PHYSICS COMPANY
A DIVISION OF HIGH VOLTAGE ENGINEERING CORPORATION

CIRCLE NUMBER 123

DIP dc/dc converters supply up to 1 W

Power Products, 1400 N.W. 70 St., Fort Lauderdale, FL 33309. (305) 974-5500. $29.20 to $31.20 (100 qty); stock to 12 wks.

PM600 Series dc/dc converters supply up to 1 W of on-board power from their 24-pin DIP housings. Fourteen single and dual-output models are available to provide 5, 12, 15, ±12 or ±15 V dc from an input of 5 or 12 V dc. All units are thermal overload and short-circuit protected. Epoxy encapsulation affords added durability.

CIRCLE NO. 404

Image module processes in real-time

Deft Laboratories, 7 Adler Dr., East Syracuse, NY 13057. (315) 437-0229.

At the heart of the Series 200 image processing module is a solid-state optical sensor. The sensor contains two surface acoustic wave (SAW) transducers, a pattern of cadmium-sulfide (CdS) squares and a finger pattern for current detection and summation—all on a substrate of lithium-niobate ($LiNbO_3$). The module finds use in image spectrum analysis, planar velocimetry, image alignment, automatic focus detection and optical system alignment. The sensor is capable of processing image functions, like the two-dimensional Fourier transform, in real-time. The module contains the sensor and support circuitry. It accommodates a standard CCTV lens and can be mounted on an optical bench or photographic tripod. A signal generator, a power supply and an output device, such as an oscilloscope or X-Y plotter, are required.

CIRCLE NO. 405

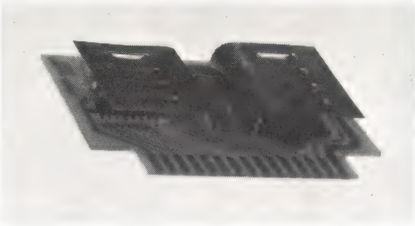
Process indicator proves versatile controller

Action Instruments, 8601 Aero Dr., San Diego, CA 92123. (714) 279-5726.

Microprocessor-based temperature indicating monitors, VIP521 and 522, offer a variety of operating modes and limit alarms. Keyboard programming establishes alarm and control setpoints, deadband and output. Trip sense and latching operation are user-selectable. A rate-of-change display reflects a true temperature trend, rather than an instantaneous rate. Miniature rocker switches select peak or valley display hold. Input can be from any standard RTD or thermocouple. The signal is fully linearized. An isolated analog output (4 to 20 mA, 0 to 1 V or others) can be programmed for full-scale output over any temperature span. BCD, RS232C or IEEE-488 outputs are optional. A 4-1/2 digit display shows centigrade or Fahrenheit readings with 0.1° resolution.

CIRCLE NO. 406

Driver/translator operates stepping motors

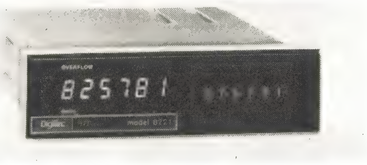


Mesur-Matic Electronics, 50 Grove St., Salem, MA 01970. (617) 745-7000. $70.

A driver/translator, Model 3616, operates 3 or 4-phase permanent magnet or variable reluctance stepping motors at up to 1.75 A/phase. The translator unit operates in full or half-step mode, with 1, 1-2 or 2 phases on simultaneously. The module accepts clockwise, counterclockwise or direct-step format index commands. Schmitt trigger inputs assure noise immunity. The unit works on up to 24 V dc over a −25 to +85 C range.

CIRCLE NO. 407

Controller counts both ways



United Systems, 918 Woodley Rd., Dayton, OH 45403. (513) 254-6251. Stock.

A bidirectional counter/controller, Model 8221, offers six-decade readout and thumbwheel preset. Count is displayed on 0.43-in. LED readouts. A user-selected four-range software filter helps reject electrical input noise. Size is 1.89 × 6.6 × 6.86 in.

CIRCLE NO. 408

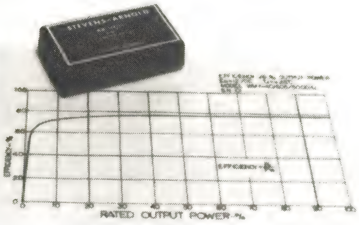
Optical encoder interfaces manual to digital world

Sensor Technology, 21012 Lassen St., Chatsworth, CA 91311. (213) 882-4100. $39.90.

An incremental encoder, Digipot Model 20-10-1972, mounts on a panel to interface manual changes to a digital system. Using a LED source, a photovoltaic sensor array and a light chopper, the device provides a digital output to up/down counters, X-Y tables, numerical control machines and similar units. Resolution is up to 256 counter/rev. Single or dual channel outputs are offered. Operating frequency is 0 to 20 kHz; output current, 10 mA maximum source or sink. Output voltage levels are TTL compatible. The encoder mounts on panels up to 3/16-in. thick through a 3/8-in. mounting hole. I/O connection is via a Molex 22-01-20 connector with 4809G female pins. Supply voltage is 5 V at 30 mA, plus external load requirements.

CIRCLE NO. 409

Dc/dc supply turns 12-V input to 5-V output

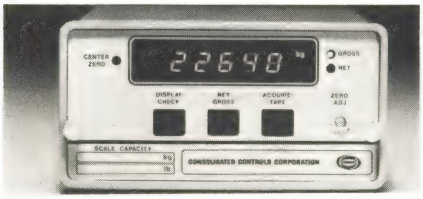


Stevens-Arnold, 7 Elkins St., South Boston, MA 02127. (617) 268-1170. $73 (100 qty); stock to 12 wks.

A dc/dc supply, WM7-40/S05/5000/U, delivers 5 V dc at 5 A for a nominal 12-V dc input over a 7 to 40-V dc input range. Efficiency is 75% and there is no derating over a −25 to +71 C operating temperature range. At 25 C, ripple and noise are 10 mV rms; line regulation, 1% maximum; load regulation, ±0.5% maximum. Overvoltage protection, short-circuit current limiting and remote sensing are standard. The unit comes in a 2.56 × 4.56 × 0.83-in. metal case. I/O pins are on a 0.1-in. grid spacing for convenient PC-board mounting.

CIRCLE NO. 410

Scale front-end shows load cell outputs

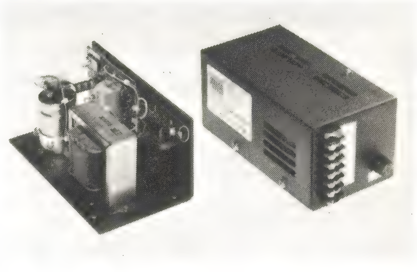


Consolidated Controls, 15 Durant Ave., Bethel, CT 06801. (203) 743-6721.

A scale front-end, UMC2000, converts the analog output of electrical load cells into digital form and displays the result as weight in either pounds or kilograms. Tare weight is acquired at the push of a button. Net or gross weight can be selected. Typically, four a/d conversions are completed each second. Load cell excitation, at 10 or 15 V, is switch selectable. Excitation power is sufficient to drive four 350-Ω load cells at 15 V. The unit provides 5-1/2 full decades of count capacity. Linearity is greater than, or equal to, 0.01% of full scale. Negative values are automatically indicated by a minus sign. Output options include parallel BCD, 0 to 10-V dc analog and 4 to 20-mA current.

CIRCLE NO. 411

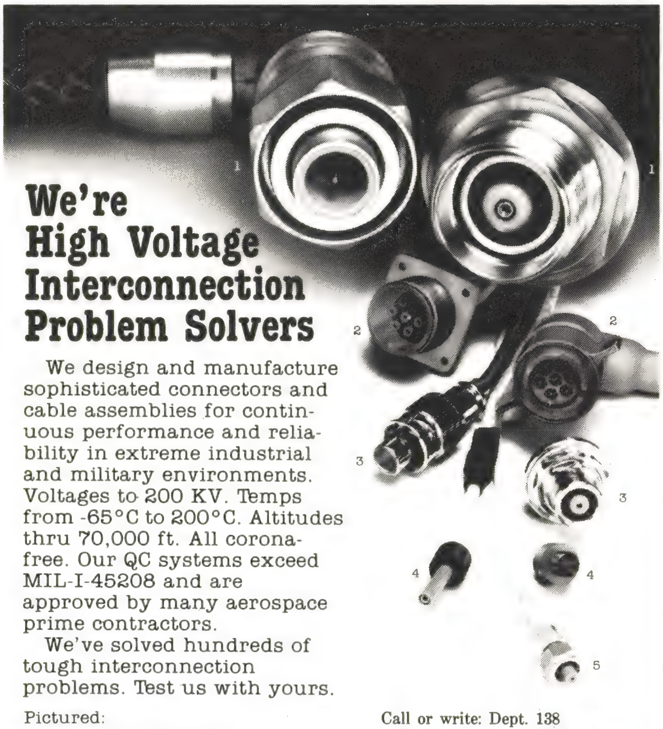
Dual-output supplies power μC/printers



Standard Power, 1400 S. Village Way, Santa Ana, CA 92705. (800) 854-6815. Stock.

A series of dual-output power supplies, 65D Series, provide service to microcomputers and associated printers. A regulated 5-V dc output supplies 3 A with ±0.1% line and load regulation. The output has full short-circuit protection with adjustable foldback current limiting. Overvoltage protection is optional. The printer output supplies an unregulated 24 V dc at 1.2 A continuous, 3-A surge. Model SPS is an open-frame version. Model CPS is covered and grounded for use in high safety environments. Both units measure 3.3 × 7.25 × 3.8 in.

CIRCLE NO. 412



We're High Voltage Interconnection Problem Solvers

We design and manufacture sophisticated connectors and cable assemblies for continuous performance and reliability in extreme industrial and military environments. Voltages to 200 KV. Temps from -65°C to 200°C. Altitudes thru 70,000 ft. All corona-free. Our QC systems exceed MIL-I-45208 and are approved by many aerospace prime contractors.

We've solved hundreds of tough interconnection problems. Test us with yours.

Pictured:
1. E-2C (40 KV series)
2. ALQ-131 (RMC series)
3. AWG-10 (JA series)
4. ALQ-94 (RLA series)
5. ALQ-126 (Sub-miniature series)

Call or write: Dept. 138

ROWE INDUSTRIES

Connectors ● Cable Assemblies ● Electronic Products
6225 Benore Road, Toledo, OH 43612, (419) 729-9761.
West Coast Office (408) 997-0157 or (213) 235-2070.

CIRCLE NUMBER 124

Electrodeposited bellows

contacts

Servometer's gold plated contact springs are actually tiny bellows with one closed end. They can be: ● Mated to diode packages ● Used in blind connections ● Leak tested for use in instruments ● Used to protect fragile crystals from probe damage ● Used to absorb vibration, temperature expansion, or tolerance build-ups.

Available in nine sizes, .037" to 0.245" O.D. and varying contact pressures from .02 to .3 oz./.001". Special designs can be made to your specifications or standard items can be modified.

FREE Sample and CATALOG

MINIATURE METAL BELLOWS

SERVOMETER

501 Little Falls Rd., Cedar Grove, N.J. 07009 (201) 785-4630

CIRCLE NUMBER 125

NEW! SHOCK AND VIBRATION RESISTANT DIP CRYSTAL OSCILLATOR

MODEL
S14F4

Dimensions: 0.25"(6.4mm)H x 0.5"; (13.1mm)W x 0.87"(22.4mm)L
Frequency: Available at any fixed frequency from 16kHz to 100kHz
Frequency Accuracy: ±.005%
Frequency Stability: ±.02%, −25°C to +75°C
Output Waveform: Squarewave, Duty cycle 40/60 with 5V supply; to drive CMOS, or, with 5V supply, 1 TTL load.
Supply Voltage: +5Vdc to +15Vdc
Supply Current: ≤1 ma at 5Vdc; ≤25 ma at 15Vdc
Shock: 1000 g's, 1 ms, 1/2 sine
Vibration: 20 grms, 10Hz to 2kHz

THE **CONNOR-WINFIELD CORP.**
West Chicago,
Illinois 60185 USA
Phone: (312) 231-5270
TWX: (910) 230-3231
Cable: CONWINWCGO

CIRCLE NUMBER 126

CHRISTIE
High Current DC Power Supplies

Symbolic of time-tested reliability.

- DC current from 40 to 1500 amps
- Voltages to 280 VDC

Write for latest detailed catalog or call toll free for application assistance.

SINCE 1929
CHRISTIE
ELECTRIC CORP.
3410 WEST 67TH STREET, DEPT. T
LOS ANGELES, CALIFORNIA 90043
(213) 750-1151
TWX 910-321-3867
(800) 421-2058

1929-1979
50 YEARS
THE SOURCE

CIRCLE NUMBER 137

Computers

Floating-point package runs on Z8002-based μCs

Hemenway Associates, 101 Tremont St., Suite 208, Boston, MA 02108. (617) 426-1931. $99.95.

A set of floating-point support subroutines run on any Z8002-based microcomputer. The subroutines, using a 32-bit binary floating-point format, provide fast arithmetic operations, integer-float and float-integer conversions, float-ASCII string representation and ASCII string-float conversions. The package can be stored in ROM; all code is position independent. Each subroutine is re-entrant and interruptable. The package requires 1412 bytes of memory and may use up to 50 bytes of stack RAM. On a Z8002 with a 3.9-MHz clock rate, all arithmetic subroutines run in 200 to 400 μs.

CIRCLE NO. 413

Rugged μC takes aim at dedicated, real-time jobs

Wintek, 902 N. 9th St., Lafayette, IN 47904. (317) 742-6802. $3995.

Sprint 68, a rugged microcomputer with built-in floppy-disk storage, functions as a dedicated, real-time, turnkey computer or development system. The unit includes a 6800 microprocessor, 48-k of RAM, dual 8-in. floppy-disk drives, an RS232C serial I/O port, the WIZRD disk operating system, an editor, assembler and 12-k Basic. Program development software includes a C compiler, PL/W compiler and UCSD Pascal. Sprint 68 accepts any of 15 modules for parallel, serial and analog I/O, as well as a 488 GPIB interface.

CIRCLE NO. 414

Pascal supports 8080/8085 systems in industrial use

Intel, 3065 Bowers Ave., Santa Clara, CA 95051. (415) 987-5020. $975.

Pascal-80, a superset of standard Pascal, supports 8080 and 8085 microprocessor development on Intellec systems. Pascal-80 offers extensions that make the language more suitable for commercial and industrial applications. Extensions include three new data types—string type, untyped files and interactive files. Also included are 28 predeclared procedures and functions. Also provided are applications-oriented data-type definitions, a TRACE facility allowing a user to monitor program execution, segmented procedure definitions to allow modular breakdown of large programs and a detailed set of compile and run-time error diagnostics. Pascal-80 software packages include a diskette with compiler, pseudocode (p-code) interpreter and demonstration programs, a user manual and a Pascal text.

CIRCLE NO. 415

Manager streamlines access to data base

Microsoft, 10800 N.E. 8th St., Suite 819, Bellevue, WA 98004. (206) 455-8080. $900.

Micro-SEED, a CODASYL-compatible system, speeds access to data base. CODASYL schema, sub-schema and area methods are used to divide and define a data base, providing easy access from user programs. The program runs under CP/M with Fortran-80 as the host language. Micro-SEED is easily transported to various 8080 and Z80 hardwave configurations. It is implemented under CP/M like a Fortran application, placing little extra burden on operating system tasks. A 64-k microcomputer system is required. A relational query language and report generator and an interactive system utility program will be available as add-ons.

CIRCLE NO. 416

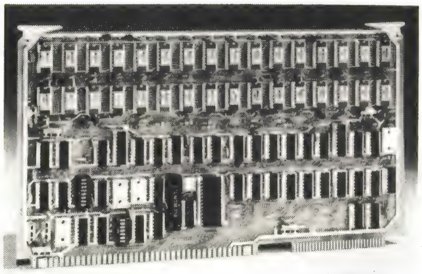
Software system supports more terminals and links

Honeywell, 200 Smith St., Waltham, MA 02154. (617) 895-3246. $210/month.

Remote Terminal Supervisor-II (GRTS-II), a communications software package, manages the flow of information between a network of remote terminals and Honeywell mainframes. The system consists of a series of interconnected software modules, linked by common subroutines and tables. The modules include system loading, initialization, common interrupt processing, executive functions, device handling, common subroutines and tables, file transfer, system dump and system macros. GRTS-II contains enhancements not found in its predecessor, GRTS, including the areas of extended memory, buffer management, extended macros, baud recognition and master console log-ons. GRTS-II supports a variety of non-Honeywell terminals.

CIRCLE NO. 417

Board supplies 48-k RAM for Multibus computers

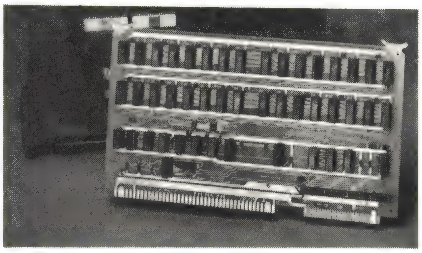


Electronic Solutions, 5780 Chesapeake Ct., San Diego, CA 92123. (714) 292-0242. $1565; stock.

A 48-k RAM board, RAM-048, offers full compatibility with Intel's Multibus. The board operates in 8 or 16-bit mode. All ICs are socketed. Twenty address bits allow 1 Mbyte addressing. Access time is 450 ns maximum; cycle time, 700 ns maximum. Power requirement is ±5 V and 12 V.

CIRCLE NO. 418

Static RAM board keeps data for Multibus μCs

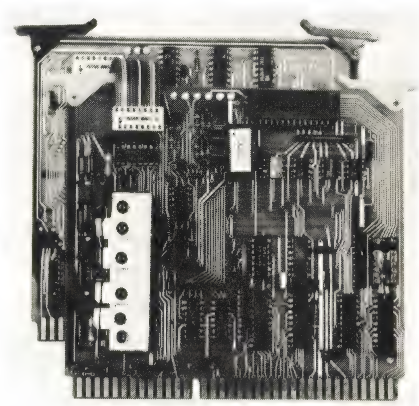


Alewife Systems, 26 Otis St., Cambridge, MA 02141. (617) 354-7337. $525 (16-k) (OEM qty); 1 wk.

A static RAM board, ASC-1600, stores up to 16 kbytes for Multibus computers. Memory maintenance requires just a battery and two charging components. Memory cycle time is as fast as 160 ns and typically 440 ns. Single supply voltage reduces the cost of systems now using dynamic RAM requiring multiple supply voltages. The board functions as a general memory add-on with separately addressable 4-k memory banks. The board is supplied with from 4 to 16-kbytes of memory. Kits are available to field upgrade boards in 4-byte increments.

CIRCLE NO. 419

Fits-all programming card ends hardware problems



E-H International, 7303 Edgewater Dr., Oakland, CA 94621. (415) 638-5656. $895.

A PROM programming card, SuperMOS, fits all Data I/O programmers, including Models 1, 2, 3, 5, 7, 9, 17 and 19. The card can be used for all n-channel EPROMs, including 32-k types. Basic operation of the PROM programmer remains unchanged. The SuperMOS card features an on-board CPU and built-in diagnostics.

CIRCLE NO. 420

SHIELD AGAINST INTERFERENCE (EMI/RFI)

LET US CUSTOM-COAT YOUR PLASTIC SUBSTRATES

PennDixon will expertly custom-coat with electrically conductive compounds of graphite, copper, nickel, silver, etc. and eliminate electromagnetic interference. Won't peel, chip or crack. Low cost protection for each specific application.

We can meet your specifications and solve your interference problems. Four complete modern coating facilities, nationwide.

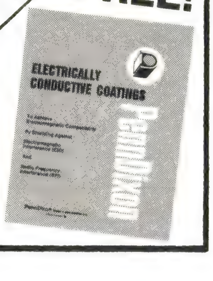
Sample parts coated on request.

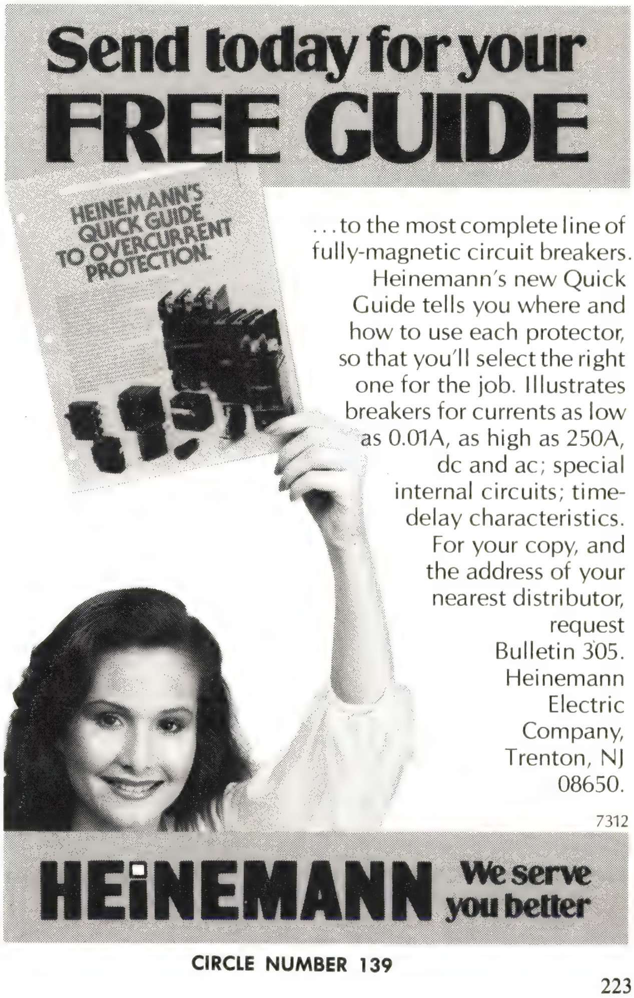
PENNDIXON
Division of Dixon Industries
A Bundy Company
P.O. Box 188
Sharon Hill, PA 19079
(215) 622-3700
Telex No. 84-5212

FREE!

Send for Folder EMI

CIRCLE NUMBER 138




HEINEMANN'S QUICK GUIDE TO OVERCURRENT PROTECTION.

Send today for your FREE GUIDE

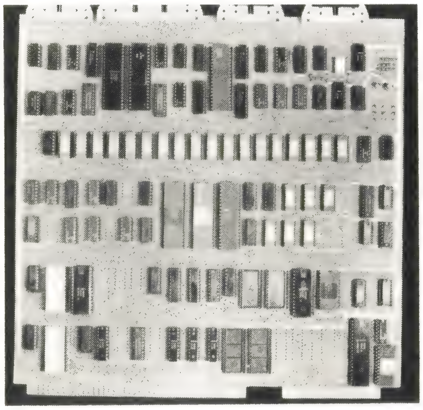
...to the most complete line of fully-magnetic circuit breakers. Heinemann's new Quick Guide tells you where and how to use each protector, so that you'll select the right one for the job. Illustrates breakers for currents as low as 0.01A, as high as 250A, dc and ac; special internal circuits; time-delay characteristics. For your copy, and the address of your nearest distributor, request Bulletin 305. Heinemann Electric Company, Trenton, NJ 08650.

7312

HEINEMANN We serve you better

CIRCLE NUMBER 139

Single-board computer supports Pascal and CP/M



DOSC, 500 Fifth Ave., New York, NY 10033. (212) 398-9810. $1495 (10 qty); stock.

A single-board microcomputer, TCB-85, supports Pascal and CP/M. The 64-k board is compatible with Intel's Multibus. Features included on-board are a dual-density floppy-disk controller for four single or two double-sided drives, an RS232 serial I/O port, a parallel printer interface and a strobed or scanned keyboard interface. A CRT controller provides up to 80 characters and 25 lines, reverse video, blink, highlighting, underline and password protection. Other features include vectored interrupts and three timers.

CIRCLE NO. 421

System interfaces carts to Micro-Nova computers

Alloy Engineering, 908 Concord St., Framingham, MA 01701. (617) 620-1710. $850 (100 qty).

A cartridge tape subsystem, Model DMN-1, interfaces Data Electronics drives to Data General's Micro-Nova computers. The subsystem allows the drive to emulate a standard 9-track NRZI tape peripheral. To the computer, the drive looks the same as a 4030 series Mag-Tape or a Nova cassette. Model DMN-1 does not require card slots or power from the mainframe. Up to two cartridge tape drives can be supported by a single controller. Either 1600 or 6400 bits/in. drives can be used with resultant formatted capacities of 3.75 or 14.5 Mbytes. The subsystem includes a controller with firmwave, dual-drive power supply, data and power cables and a 5.25-in. drive panel with LEDs.

CIRCLE NO. 422

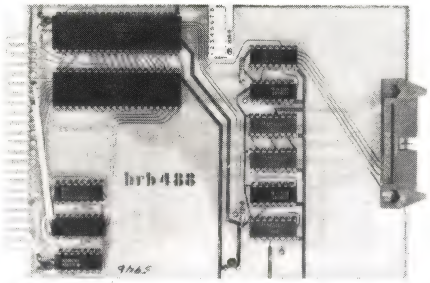
Module keeps time/date for Multibus systems

Micro/Sys, 1353 Foothill Blvd., La Cañada, CA 91011. (213) 790-7957. $395; stock to 3 wks.

A timekeeping module, MC1460, provides time and date information for Multibus systems. CPU involvement is not necessary in the time-keeping operation. Separate, random access input ports provide binary data representing the month, day, hour, minutes and seconds. CMOS logic is used, allowing external battery powered operation during outages. In addition to date and time functions, the board includes an interrupt system. Periodic interrupts are enabled under software control to interrupt a CPU at intervals ranging from 10 ms to 24 h, including the 50-ms rate required by Intel's RMX-80 software. Line frequency is used as a timing reference. During battery operation, an on-board crystal oscillator maintains proper time.

CIRCLE NO. 423

Controller moves data on the IEEE 488 bus

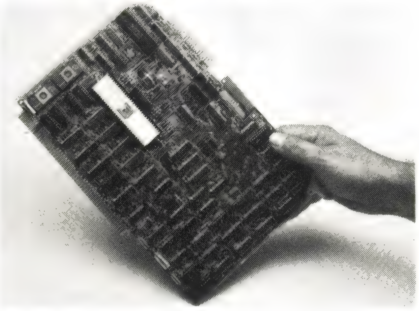


Wintek, 902 N. 9th St., Lafayette, IN 47904. (317) 742-6802. $199.

An interface module handles all handshake protocols for controlling and moving data between multiple instruments on the IEEE 488 instrument bus. Talker and listener functions are performed by the MC68488, a general-purpose interface adapter IC. These functions include primary address recognition, secondary address capability, complete source and acceptor handshakes, programmable interrupts, RFD holdoff to prevent data overrun, serial and parallel polling capability and synchronization trigger output. Controller functions are performed by the software driver, Buscon. These include system controller functions, receive control from another controller, pass control to another controller, sending of interface messages and parallel and/or serial polling.

CIRCLE NO. 424

Controller supports four double-sided drives



Texas Instruments, P.O. Box 1433, MS 6404, Houston, TX 77001. (713) 494-5115. $845; 4 wks.

TM990/303, a floppy-disk controller compatible with the TM990 series of microcomputer boards, supports up to four double-sided drives. The board is programmed by a CPU for data encoding formats and number and type of diskette drives. Single-density drives or FM or MFM dual-density drives are handled. Data transfer format and stepper motor rates are programmable. The controller is compatible with IBM 3740 and TI disk formats. Features include precompensation, 5 or 8-in. diskette compatibility, soft sector compatibility, internal phase acquisition and address mark detection.

CIRCLE NO. 425

Processor board supports parallel/serial/video data

Nortek, 2432 N.W. Johnson St., Portland, OR 97210. (503) 226-3515. $525 to $1950.

A programmable communications processor, PCP-11L, supports any mix of 8-bit parallel, asynchronous or synchronous serial and color video graphics. The single-board peripheral is compatible with the entire DEC LSI-11 family, including the LSI-11/23. Using an optional dialer interface, the processor can be programmed to provide auto-answer, auto-dial support for virtually any serial communications protocol, including asynchronous, Bisynch, SDLC and DDCMP. Most protocol overhead is managed on-board, making choice of formats virtually invisible to a host system. Data transfer rates are in excess of 48 kbaud. Low-resolution NTSC color video alphagraphics are optionally available, including fully programmable RAM-resident text fonts. Control software can reside on-board in non-volatile memory or can be down-loaded from a host computer.

CIRCLE NO. 426

New Literature

GaAs FET amplifiers

Technical information, product specifications, application data and outline drawings of microwave GaAs FET amplifiers are given in a 16-page guide. The Narda Microwave Corp., Plainview, NY

CIRCLE NO. 427

Burn-in systems

The operation and features of the Series 532 burn-in system for microcircuits, diodes, transistors, resistors and capacitors are given in a product sheet. Trio-Tech International, Burbank, CA

CIRCLE NO. 428

Dc power supplies

Submodular dc-output power supplies are described in a 16-page catalog. Fifty-nine different models have output voltages ranging from 1.20 to 30 V dc at 0.40 to 75 A. Powertec, Chatsworth, CA

CIRCLE NO. 429

Electronic hardware

General specifications and finishes, mechanical drawings and tabulations of electronic hardware components are given in a 150-page catalog. Metric and decimal conversion and equivalency charts are included. Accurate Screw Machine Co., Nutley, NJ

CIRCLE NO. 430

Video display terminals

Specifications and features of video display terminals and the 300 series Ballistic printer are given in a six-page brochure. Lear Siegler, Anaheim, CA

CIRCLE NO. 431

Components, hardware

A 104-page component/hardware catalog features an updated format to expedite location of more than 20,000 items. The catalog includes a parts number cross-index, as well as an alphabetized product grouping index. Herman H. Smith, Brooklyn, NY

CIRCLE NO. 432

Processors, μC systems

MicroNOVA: The Mark, 20 pages, presents a line of chip-level processors, computers-on-a-board and full microcomputer systems. Features such as peripherals, industry-standard communications and development and runtime software, are discussed. Data General, Communications Services, Westboro, MA

CIRCLE NO. 433

There's a Standex Switch or Relay in Every One of These Products

Creative engineers specify Standex parts because: we offer innovative designs at competitive cost; our broad range of reed switches and relays, made with rigid controls, satisfies the most demanding applications; and *we meet delivery schedules!* Call us.

Standex Electronics
4538 Camberwell Rd., Cincinnati, OH 45209 Tel: (513) 871-3777
a Standex company

CIRCLE NUMBER 131

10 AMP
50 to 1,000 PRV

WIRE LEADS

FREE SAMPLE

RECTIFIER BRIDGES

PK Series! 150 Amp. surge. 1,500V RMS dielectric strength **U.L. Component Recognition.** Lots of features. Competitively priced. Write or use Inquiry Number for O.E.M. application card for free samples and condensed catalog of bridges.

edi®
Buy from the specialist
electronic devices inc.
21 GRAY OAKS AVE., YONKERS, N.Y. 10710
(914) 965-4400. TWX 710 560-0021

For application information, call Toll Free: 800 431-1532

CIRCLE NUMBER 132

(continued from page 225)

Piezoelectric ceramics

Piezoelectric effects, characteristics, vibratory modes, ceramic materials and their piezo, physical and electrical properties, temperature effects, coupling characteristics and dielectric factors are described in a 16-page brochure. Annotated drawings of transducers capable of performing in various directions are accompanied by their polarization directions, vibration direction and coupling factors. Piezoelectric Crystal Div., Quartz Products Corp., Plainfield, NJ

CIRCLE NO. 434

Components

A 60-page components catalog offers a comprehensive cross-reference section. Product lines include: electrolytic, aluminum, ac and film-metalized capacitors, mica dielectric capacitors, disc ceramic capacitors, EMI filters, relays and decade boxes. Cornell-Dubilier, Newark, NJ

CIRCLE NO. 435

Connectors

Connectors listed in a catalog range from economical DIP sockets to subminiature tube sockets. TRW Cinch Connectors, Elk Grove Village, IL

CIRCLE NO. 436

X-Y recorders

Specifications of X-Y recorders are given in a four-page brochure. Gould, Instruments Div., Cleveland, OH

CIRCLE NO. 437

Photomultipliers

An eight-page brochure describes test and design considerations for the operation of photomultiplier tubes in severe environments. EMI Gencom, Plainview, NY

CIRCLE NO. 438

Telecommunications

Design and operational specifications of telecommunications and voice readout systems are included in a 12-page catalog. Master Specialties, Costa Mesa, CA

CIRCLE NO. 439

Positioning controls

Positioning and tracking control products, for use in computer peripherals, radar and other displays, are described in a 16-page catalog. Measurement Systems, Norwalk, CT

CIRCLE NO. 440

Piezoelectric alarms

Electrical and mechanical specifications of piezoelectric audio alarms are given in a six-page brochure. Murata Corporation of America, Marietta, GA

CIRCLE NO. 441

Analog ICs

Analog integrated circuits in linear and data-acquisition components are described in a 44-page data book. The book is divided into two sections: one provides information on product assurance, testing, recommended handling; the other provides data on 24 individual chips with dc and ac specifications, chip layout and a functional layout. Letterhead requests only. Harris Semiconductor Products Div., P.O. Box 883, Melbourne, FL 32901.

INQUIRE DIRECT

NEW HTL 80
ADJUSTABLE TRIGGER-LOCK® LATCH

The Lowest Installed Cost Trigger-Lock® Latch!

- Adjustable to both door and frame
- Installs with single self-tapping screw
- Can be used in metal or wood — large radiused corners for routing
- Opens and closes with simple push
- Self-Locking adjustment to any frame thickness
- 3 to 1 mechanical advantage closing a door
- Bolt forms handle & flag when triggered open
- Adaptable to a key lock behind trigger
- Beautiful lines enhanced by chrome plating
- Immediately available from local stock

Write or call today for a brochure!

IN STOCK

Latching Specialists Since 1939
THE HARTWELL CORPORATION
900 S. Richfield Rd., Placentia, Calif. 92670
(714) 993-4200. Branch Offices & Warehouses
Chicago, Ill. (312) 253-7820; Fort Worth, Tex. (817) 535-0824; Hackensack, N.J. (201) 342-2964

CIRCLE NUMBER 133

Seek and Ye Shall Find in the GOLD BOOK

With over 5500 Product Headings and over 10,000 US and non-US companies listed, virtually every electronic product—component, sub-system, and system—can be found in ELECTRONIC DESIGN's GOLD BOOK. Your search for products starts here. In the World's Most Complete Electronics Directory.

"Over 108,000 Distributed Worldwide"

Electronic Design's
GOLD BOOK
THE WORLD'S MOST COMPLETE ELECTRONICS DIRECTORY

Hayden Publishing Company Inc.
50 Essex St., Rochelle Park, NJ 07662 • 201-843-0550

We're still making convertibles

Shift lever and go from alternate to momentary action.

They're not the last convertibles; they're a Unimax first that lets you minimize inventory by offering maximum flexibility in a single LPB device, ideal for short runs and prototypes. Like our other TH Series lighted pushbutton switches, they're Status Symbols—combining the appearance, features and quality that make your product (and you) look good.

Not every TH Series switch is a convertible, but they do all provide T-1¾ lamp compatibility, large double terminals, metal (not plastic) mounting nuts, behind-panel space economy, 1-to-4 pole availability and 5 Amp, 250 Volt ratings.

Quality features. Status Symbol benefits. Unimax advantages, all.

Within the prestigious TH Series, you can select electromechanical and electronic switches in both lighted and unlighted versions, and with a broad, broad range of bezel and lens sizes and shapes.

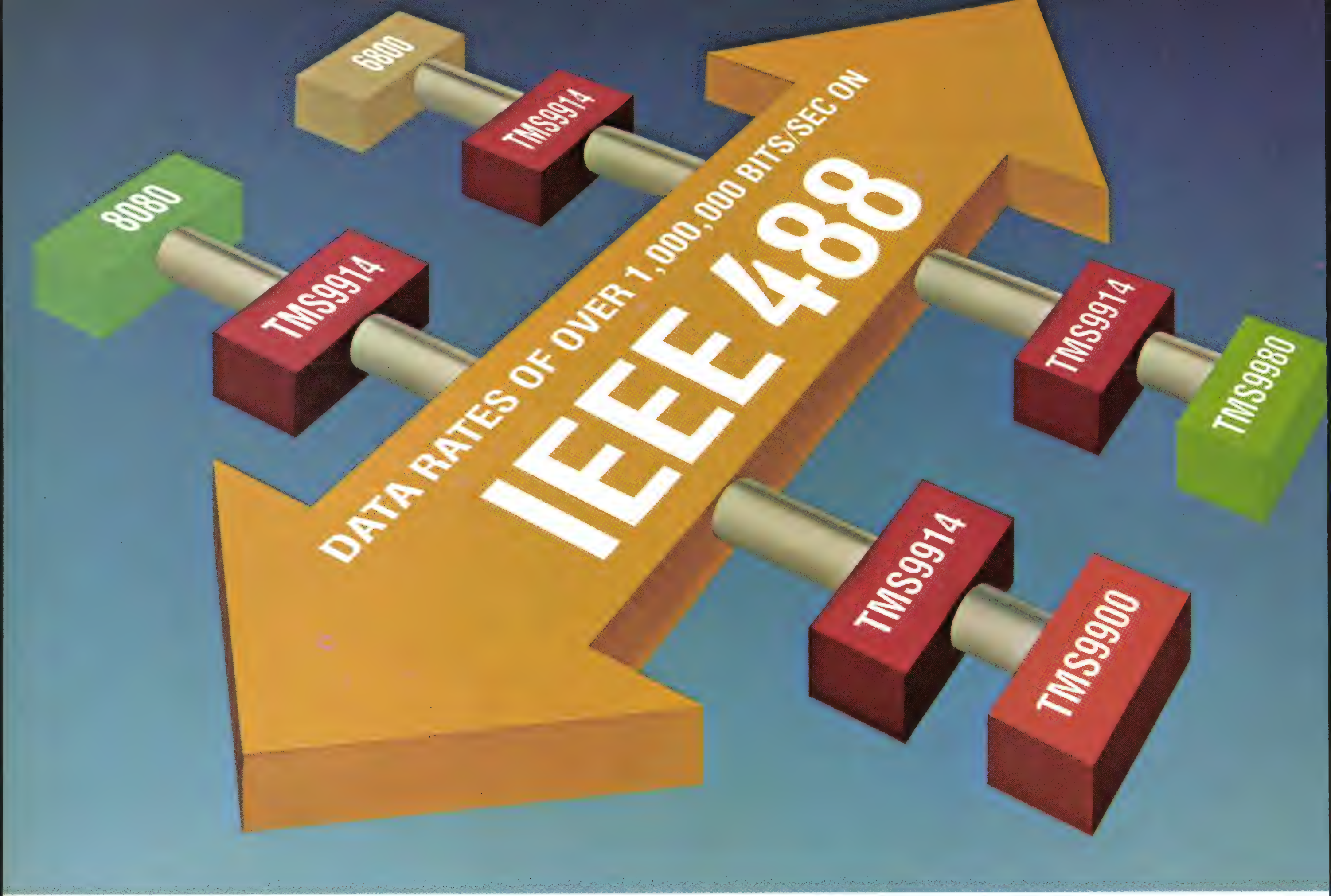
Choose bezels that are tapered, straight, covered... even mushroom caps. Get pushbutton, key-operated and rotary versions.

Specify interlock switches, oil-tight switches, and multiple switch assemblies. And always ensure the best possible solution to your switching needs.

For complete details on how the new generation of Unimax Status Symbols can help you, write or call for details on TH Series LPB's today: Unimax Switch Corp., Ives Rd., Wallingford, CT. 06492; Tel. (203) 269-8701.

Unimax Switch®

CIRCLE NUMBER 142



New from Texas Instruments . . .

Complete microprocessor interface at minimum cost. First single-chip GPIBA. Meets IEEE Standard 488-1978. 100%.

TMS9914. The first General Purpose Interface Bus Adapter to offer talker, listener and controller capabilities all on one chip.

The first 100% implementation of the industry standard parallel communications interface . . . IEEE 488.

And the first to let you talk to all of today's popular microprocessors.

Used with the recently introduced GPIB linear drivers, SN75160 and SN75161, TMS9914 provides a complete microprocessor interface.

It also meets the requirements devised by instrumentation manufacturers to define all electrical, timing and mechanical specifications.

Moreover, it ensures compatibility and accurate data transfer between intruments and computers.

TMS9914 is ideal for instrumentation applications. But that's not all. It's also perfect for use in microprocessor-based systems wherever data must be transferred between processors.

Thirteen memory-mapped registers control communications between the TMS9914 and the microprocessor. And, because of its interrupt capability, the bus doesn't have to be continuously polled. So it can respond to changes in the interface configuration. Fast.

Operating at speeds up to 250K bytes per second, TMS9914 is fully two to five times faster than competitive interface bus adapters.

TMS9914 features

- System controller capability
- Pass control capability
- Single or dual address capability
- Secondary address capability
- Serial poll
- RFD holdoff on data transfer
- Service request
- Remote/local
- Local lockout

Compatible with most microprocessors, most DMA controllers, the TMS9900 Family and TMS9911 DMAC, the new TMS9914 costs only $25.60 in 100 pc. quantities.

It's available through your nearest authorized TI distributor.

For more information, call your local TI sales office, or write Texas Instruments Incorporated, P.O. Box 1443, M/S 6404, Houston, Texas 77001.

Fifty Years of Innovation

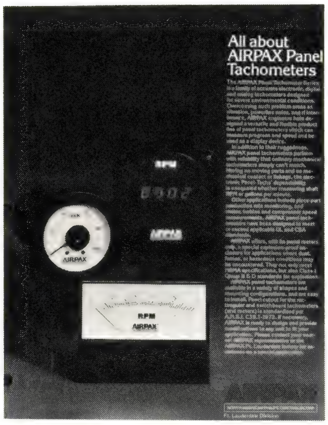
TEXAS INSTRUMENTS
INCORPORATED

© 1979 Texas Instruments Incorporated

85583A

CIRCLE NUMBER 110

(continued from page 226)



All about AIRPAX Panel Tachometers

Panel tachometers

Specifications, dimensional drawings and a mounting and wiring diagrams of panel tachometers are given in an eight-page catalog. Airpax, Fort Lauderdale, FL

CIRCLE NO. 442

Ceramic capacitors

Class I temperature stable and temperature compensating capacitors and Class II general-purpose disks are described in a 12-page catalog. Multi Products International, Clifton, NJ

CIRCLE NO. 443

Data communications

A 29-page catalog features a line of data communications test equipment, including on-line CRT monitors, TDMs and FDMs, error detection devices and breakout panels. International Data Sciences, Lincoln, RI

CIRCLE NO. 444

LED scanners

Self-contained ac and dc, LED photoelectric scanners are described in a 16-page catalog. Included are hookup diagrams, part numbers, dimensional drawings and accessories. Banner Engineering, Minneapolis, MN

CIRCLE NO. 445

Hardware, software

Hardware, software, peripherals and support for the Eclipse C/150, C/350 and M/600 computer systems are described in a brochure. Data General, Communications Services, Westboro, MA

CIRCLE NO. 446

Vendors Report

Annual and interim reports can provide much more than financial position information. They often include the first public disclosure of new products, new techniques and new directions of our vendors and customers. Further, they often contain superb analyses of segments of industry that a company serves.

Selected companies with recent reports are listed here with their main electronic products or services. For a copy, circle the indicated number.

Heath Tecna. Electronics and defense; building products and protective finishes; air-transportation products.

CIRCLE NO. 447

Raymond. Electromechanical and electronic devices and torquing equipment; time-recording equipment; telephone system components.

CIRCLE NO. 448

General Signal. Environmental and fluid process controls; transportation controls; energy distribution and control.

CIRCLE NO. 449

Engelhard Minerals & Chemicals. Minerals, metals and ores.

CIRCLE NO. 450

Loral Corp. Electronic warfare; electronic communications; aerospace components; plastic packaging.

CIRCLE NO. 451

Unitrode. Semiconductors.

CIRCLE NO. 452

Advanced Micro Devices. LSI memories; microprocessors.

CIRCLE NO. 453

Intelsat. Global telecommunications satellites.

CIRCLE NO. 454

Park Electrochemical. Multilayer circuit materials; nameplates; chrome-plated zinc; polymers.

CIRCLE NO. 455

Degussa. Metals; chemicals.

CIRCLE NO. 456

Computervision. CAD/CAM systems and products; semiconductor production automation products.

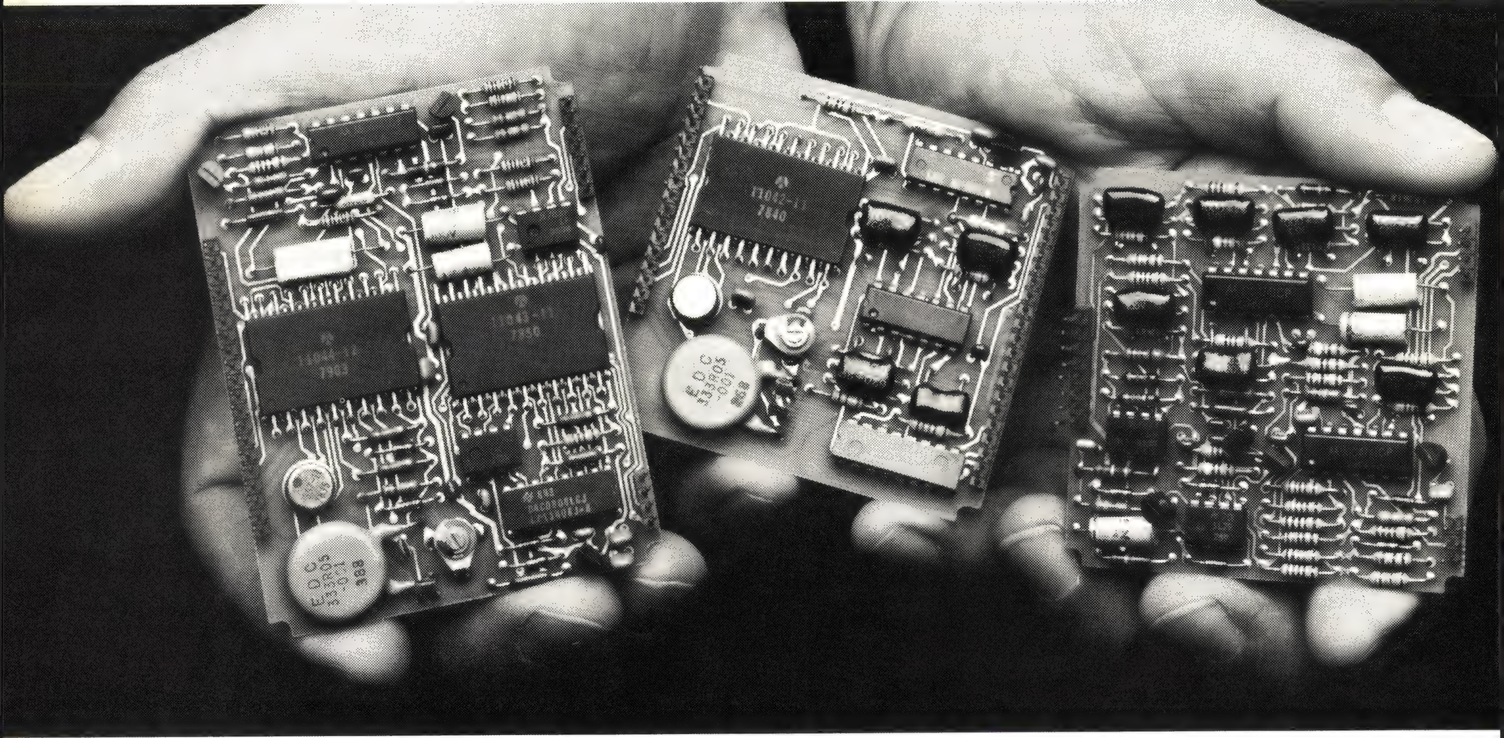
CIRCLE NO. 457

Electronic Design

Advertising Sales Staff
Rochelle Park, NJ 07662
Eastern Regional Sales Manager:
Thomas P. Barth
Robert W. Gascoigne
Constance McKinley, Becky McAdams
Roberta Renard, Stan Tessler
Diana Andress, Carol Helton
Sales Assistants:
Deborah DiPilla, Francine Guerra
Dale Siegel, Betsy Tapp
50 Essex St.
(201) 843-0550
TWX: 710-990-5071
(HAYDENPUB ROPK)
Philadelphia
Thomas P. Barth (201) 843-0550
Boston
M. E. "Casey" McKibben, Jr.
113 River St.
Waltham, MA 02154
(617) 893-4441
Chicago 60611
Thomas P. Kavooras
Craig L. Pitcher
Sales Assistant:
Christine Perkins
200 East Ontario
(312) 337-0588
Cleveland
Thomas P. Kavooras (312) 337-0588
Texas
Craig L. Pitcher (312) 337-0588
Los Angeles 90045
Stanley I. Ehrenclou, Burt Underwood
Sales Assistant:
Betty Fargo
8939 South Sepulveda Blvd.
(213) 641-6544
San Francisco
Western Regional Sales Manager:
Robert A. Lukas
Neal Manning
Sales Assistant:
Nancy Miguelgorry
1307 South Mary, Suite 212
Sunnyvale, CA 94087
(408) 736-6667
United Kingdom-Scandinavia
Constance McKinley
Germany
Annemarie McCalla
50 Essex St.
Rochelle Park, NJ 07662
(201) 843-0550
Europe
W.J.M. Sanders
S.I.P.A.S.
Raadhuisstraat 24 - P.O. Box 25
1484 EN Graft-de-Ryp, Holland
Tel: 02997-1303 and 3660
Telex: 13039 SIPAS NL
Telegrams: SIPAS-Amsterdam
Annick Wolff
Promotion Presse Internationale
7 ter Cour des Petites Ecuries
75010 Paris, France
Telephone: 247-12-05
Robert M. Saidel
Technimedia International
Piazzale Cadorna 4,
20123 Milan, Italy
Tel: 80 16 46
Telex: 25897 Utidioma
Tokyo
Haruki Hirayama
EMS, Inc.
5th Floor, Lila Bldg.,
4-9-8 Roppongi
Minato-ku, Tokyo, Japan
Phone: 402-4556
Cable: EMSINCPERIOD, Tokyo
Recruitment Advertising Manager
Roberta Renard (201) 843-0550

ABP BPA

R24. The first 2400 bps modular modem.



Rockwell's compact MOS-LSI modem gives new physical design freedom.

Micro Power

Rockwell's R24 Modem is the most compact 2400 bps MOS-LSI modem available today. Its small size and modularity give designers a whole new form factor flexibility. Requiring only 25 square inches of system area, the R24 is ideal for terminals and communications equipment.

The R24 provides functional flexibility also. Of its 3 modules, one is the transmitter, two the receiver. Terminal designers can offer transmit-only or receive-only options. And, the R24 is Bell 201 B/C and CCITT V.26 and V.26 bis compatible.

With its major functions in LSI circuits, the R24 is solid-state reliable and economical. It can be configured for operation on either leased lines or the general switched network. And, each low-profile module can be plugged into standard connectors or wave soldered onto system PC boards.

A new generation of modems from the company that's delivered more high-speed modems than anyone in the world. That's Rockwell Micropower!

For more information, contact Modem Marketing, Electronic Devices Division, Rockwell International, P.O. Box 3669, RC 55, Anaheim, California 92803. (714) 632-5535.

Rockwell International

...where science gets down to business

CIRCLE NUMBER 108

Motorola Semi remakes its future; LSIs lead the way

Summer 1976: The semiconductor industry begins to pull out of the 1974 recession—the sharpest decline in semiconductor history. Significant market growth is predicted over the next 12 months. The industry, fueled by LSI circuit technology and product developments, is on the rise again. But the top executives of Motorola have misgivings. Although the industry-wide recession is over, the growth prospects of the large Phoenix-based semiconductor division remain in doubt.

MOS sales lag. The company's 6800 MOS microprocessor family runs a poor second to Intel's 8080 processor, even though analysts consider the 6800 a better design. Developments in high-density MOS memories limp far behind the industry, indicating a need for expensive new programs. The Division's leadership in complementary MOS has not yet translated into products for the changing LSI market. Moreover, Motorola has dropped out of the growing bipolar digital logic business and even appears to be losing ground to Bay-Area companies in the linear integrated circuit market—a product area that it once dominated. In fact, the only bright spot in the Motorola portfolio is its acknowledged leadership in discrete technology, especially power devices, and a continued healthy position in ECL technology.

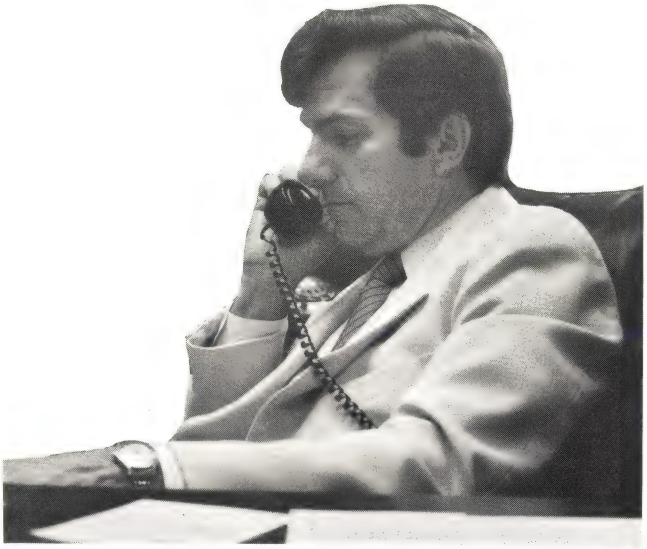
Winter 1979: In the past three years, Motorola's semiconductor division has significantly outperformed the industry. The company's MOS sales have grown faster than those of any other major manufacturer. The division's recently introduced MC68000 successor to the MC6800 microcomputer—a family considered to be the most powerful in the industry—has taken hold. Motorola's MOS product portfolio boasts a breadth unequaled by that of any competitor: a 200-ns 64-k dynamic RAM, a full line of byte-wide and by-one static RAMs, the latest 16-k and 32-k EPROMS, 64-k read-only memories and, unique to Motorola, 1 and 4-k CMOS memories.

Motorola re-enters the digital bipolar market with a full-blown line of low-powered Schottky TTL parts, and maintains its leadership in ECL LSI and gate-array technology. Most significant, Motorola is now an industry leader in communication-dedicated LSI devices, having anticipated the competition with MOS LSI Codec designs, integrated filters and μP-converter devices. Meanwhile, the company dominates the automobile electronics marketplace with a host of MOS and bipolar designs for under-the-hood and dashboard-related modules, while it stays ahead in CMOS logic and linear integrated circuits.

What made the difference between an uncertain outlook in the beginning of 1976 and this solid, dominant, across-the-board position in the beginning of 1980?

Most analysts agree that the difference is Al Stein, recently appointed vice president and assistant general manager of Motorola's Semiconductor Group.

After an 18-year stint at Texas Instruments (Dallas), Stein arrived at Motorola in July, 1976, to head up the Integrated Circuits Division under John Welty, general manager of the Semiconductor Group. The following interview touches on his first impressions of Motorola, and the actions and policies he implemented over the last four years in turning around its semiconductor division.



My method of management? Get involved down to the lowest levels, know your people, define expectations and monitor them closely.

For 18 years you were at TI, admittedly a highly structured management environment. What were the principal differences between TI's operations and Motorola's?

What hit me initially was the lack of a solid P&L document—the profit and loss report card—at Motorola. The way the P&L statements were organized, it was difficult to ascertain whether a particular business was making or losing money. Worse, it was next to impossible for a manager to evaluate a given product line. While P&L-type documents existed, each had a plethora of inputs from a multitude of in-company organizations, which made them very complex and very difficult to understand. Determining who was responsible for what, and who had made what commitment under whose authority, was practically impossible. In short, I found an organization consisting of many small groups without clear-cut authority or methods of self-evaluation.

How was this disorganization corrected?

First, we reconstructed the product groups into well-defined P&L business organizations, where each product manager became (in essence) a president of a small company. He was given the responsibility, authority and organization to run his business successfully. Under these P&L centers, I reorganized engineering, production and manufacturing, production control and product marketing pertaining to the product group; everything necessary to manage an integral business activity. We then set up a regional P&L system; this system generated a complete P&L for each product line, against which a business organization could be measured as a stand-alone entity and judged according to its success or failure.

How did this tight P&L structure influence Motorola's rather loose management style?

The success of highly-structured P&L centers requires highly-structured management control. Upon arriving at Motorola, I found that the prior management had not really been involved in running the business. They had provided a high-level philosophical involvement rather than a day-to-day benchmark judgment.

I think that we've changed all that. Each manager and his organization are responsible for detailed programs, which are put in writing. We review and approve the requirements for people and equipment, and we review the entire program monthly. In short, we measure performance against detailed forecasts. We are very goal-oriented.

Motorola has a central marketing organization. How do the product centers in your division tie in with central marketing?

We need to go back a bit. When I first arrived at Motorola, the various businesses were operating with practically no forecast-review—a marketing forecast based on expectations of bookings. True, the factory ran on a yearly budget, which was reviewed quarterly, but no real-time day-to-day factory production schedule was harnessed to a booking schedule. This meant that a sudden turndown in bookings (like that which occurred in 1974) did not get reflected back into the factory production schedules. Backlogs accumulated rapidly and remained to plague us for months.

Today, we go through a very religious forecasting review of bookings with our central marketing organization. We are then in a position to integrate the bookings plan with our manufacturing plan. With this system, we adjust our manufacturing plan each month—based on new bookings, accumulated backlog, product line delinquencies and so on.

How did the Motorola people react to this change in structure?

When I think back over the first year, I realize how difficult it was for all of us; for me and for many of the people who worked with me. It was rumored that 100 different guys were going to leave the company immediately. A great uncertainty hung over everyone involved.

It was a question of changing attitudes. When I first arrived, many people would leave at four-thirty; absolutely no weekend work was contemplated; and if anybody ever thought about having a Saturday meeting, there was every reason in the book why that couldn't happen. It was an attitude of casualness—a place to work but not to grow professionally. But somehow, I was able to convince most of our key people that we needed discipline to achieve the growth that everyone wanted. Today, our attitude is "make it happen."

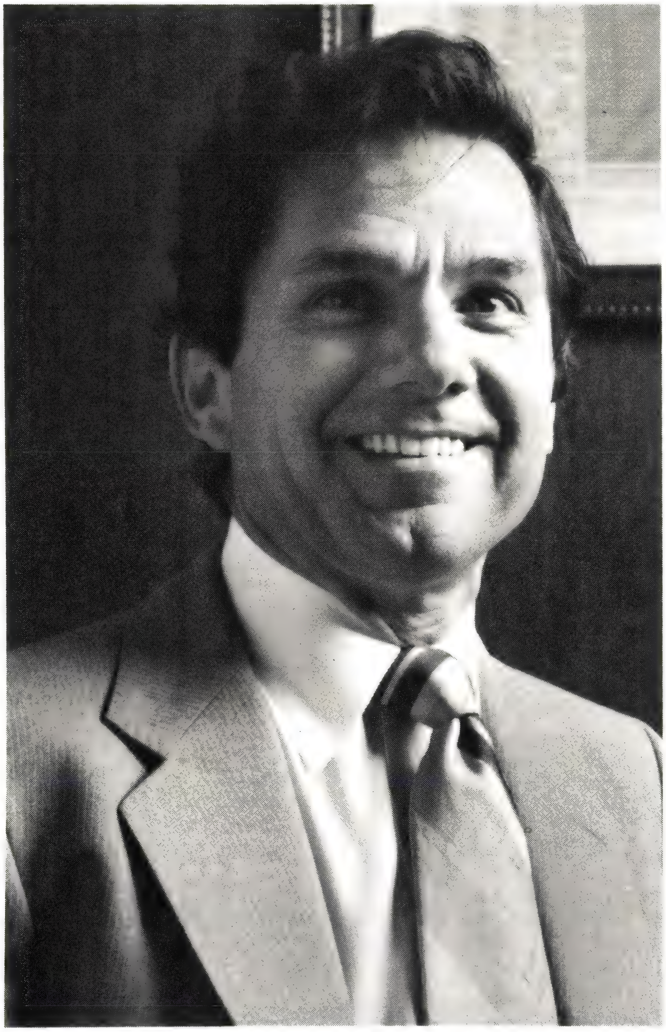
At first, however, I was very frustrated and consequently got tough on a lot of people, and that toughness ricocheted throughout this organization. Bad results show up very quickly; and since I'm a very direct person, I react very quickly and directly to poor performance.

At first the people here were not accustomed to this reaction—they had simply never experienced that kind of management involvement. My method of management? Get involved down to the lowest levels, know your people, define expectations and monitor them closely. If a person does a good job, I'll reward him in every way I can—verbally, with a written appreciation or, as appropriate, with financial rewards. On the other hand, if he doesn't meet our expectations, I will deal with that as well. It's working that way now, I'm happy to say. But those first months, if I said it once, I said to myself a hundred times, "What the hell am I doing here?"

Besides forming P&L centers and instituting a program of monthly reviews, how were you able to change the environment from one so loosely-structured to one so tightly knit?

A big part was instituting a procedure for cross-fertilization of ideas among the various organizations. When one member of our organization had a good idea, we introduced it as an innovation throughout our division and, in the process, brought teams of people together.

Take the front-end process. The guys in wafer-processing are key in this business, so we got the managers in each of the groups together in separate sessions for brain-storming improvements in material handling, wafer processing and so on. We established front-end disciplines throughout all product lines, upgrading our clean rooms, concentrating on yields, things like that. In six months to a year after an interdisciplinary exchange of information, we began seeing differences which translated into higher yields and higher product output, increased product availability, better billing profiles and, finally, a sharp upturn in profitability. And so it went throughout the entire organization.



We review the entire program monthly, and measure performance against detailed forecasts. We are very goal oriented.

When you came to Motorola, the company was considered primarily a discrete house. Now it is considered a leader in integrated circuit technology. How did that change come about? What made the difference?

When I first arrived the semiconductor division was very much oriented to the discrete business—even in its organization, the Semiconductor Group pointed toward discrete devices. Everyone knew that the most dynamic aspect of the business was integrated circuits, yet, here at Motorola integrated circuits were considered more or less a stepchild.

The IC performance was very poor, its profitability was nonexistent, and so top management was reluctant to pour the required funds into support functions and production expansion. Once we came onstream in Austin with our advanced MOS product lines and showed a nice second-quarter profit in 1977, the feelings about integrated circuits began to change. During 1977, we began to achieve growth and profitability milestones and gain respectability throughout our Group and throughout Motorola. Now, we have achieved one of our major IC goals: a parity with discrete shipments.

We've begun to pull away and penetrate markets in key product areas. The IC divisions are no longer treated as second fiddles but as leading performers that must be given the resources to maintain a high-powered, fast-growing business. Now I don't want to leave you with the impression that our discrete business is unimportant. In fact, that group's overall leadership and industry are what we need to shoot for in integrated circuits.

Do you think your 18-year experience in the highly-structured TI environment has been a help to you at Motorola?

TI is an extremely structured and extremely well-run company—from the chief executive officer and president right down through the organization. While it is hard for me to gauge just how valuable the TI environment has been to me as a manager, I believe in most of the disciplines that I learned there. I believe in an organization that creates priorities and sets strategic directions. I believe in getting your people behind these directions.

I've stressed the team aspect of my approach to management. Clearly somebody has got to run the team, and I'm trying to do that with the help of our key managers. But I've realized that a manager must stimulate the rest of the team by setting realistic goals, by giving people the authority and the materials to achieve those goals and then by rewarding those who succeed. In a business as complex as semiconductors, you have to put together teams that complement each other and, in the process, build a dedicated, fast-moving organization. If there is any one formula for our success, it lies in this team concept.■■

Electronic Design

recruitment ads

PLACE YOUR AD AT ONLY $60 PER COLUMN INCH IN

Electronic Design

YOU REACH ENGINEERS WITH TITLES LIKE THESE:

• Chief Engineer • Development Engineer • Design Engineer • Project Engineer • Electronic Engineer • Engineer-Supervisor • Section Leader • Staff Engineer • Systems Engineer • Test Engineer • Standards Engineer • Master Engineer

Total Qualified and Paid 112,000

Electronic Design RECRUITMENT ADVERTISING RATES

15% commission to recognized agencies supplying offset film negatives. 2% 10 days, net 30 days. Four column makeup. Column width 1-3/4" x 10"

SPACE	DIMENSIONS Wide x Deep	COST
*One column inch	1-3/4" x 1"	$65.
1/8 page (1/2 col.)	1-3/4" x 5"	$322.
1/4 page (1 col.)	1-3/4" x 10" Vert. 3-1/2" x 5" Hor.	$644.
1/2 page (2 cols.)	3-1/2" x 10" Vert. 7" x 5" Hor.	$1,287.
3/4 page (3 cols.)	5-1/4" x 10"	$1,931.
1 page	7" x 10"	$2,574.

REVISED RECRUITMENT & CLASSIFIED RATES

	1X	4X	7X	13X	19X	26X	39X	52X
*Per Column Inch	$65	$63	$59	$54	$52	$50	$49	$48

STATE OF THE ART TECHNOLOGY, CAREER ORIENTED OPPORTUNITIES, FLORIDA LIVING

Frank Leonard Personnel knows what's important to you.

Yes, the proper experience and capabilities are important, but Frank Leonard Personnel places people, not paper. Our work with people means working with personalities, individual goals, families — all the things your resume can't tell us. We know our client companies very well, now we'd like to know you.

Design Engineers: BSEE/MSEE at least 2 years experience, Digital Design TTL, ECL, CMOS. To work in circuit design, high speed digital modems.

Continuation Engineers: Person to follow new and custom designs from engineering to production. Test digital systems to chip level and solve hardware/software problems.

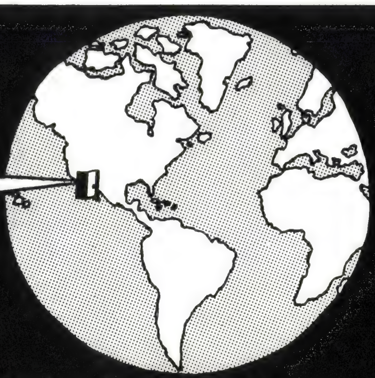
Test Engineers: Person to work in production test, ATE Design and instrument calibration.

(813) 872-1853

frank leonard personnel

Suite 100-D, 1211 North Westshore Blvd., Tampa, FL 33607

WELCOME TO THE WORLD OF *TRW* SEMICONDUCTORS



Finally there's a company dedicated to giving engineering professionals what they deserve. TRW Semiconductors is providing the most advanced technical challenges along with the promise of individual recognition and high visibility. It's our way of proving that your engineering expertise really counts and that you won't be just another face in the crowd.

And when you consider TRW Semiconductors don't forget to consider our beautiful Southern California location and all the advantages to be found in this sunny, warm, exciting community. The time has never been better — consider the following career opportunities for RF and Power Engineers and Technicians.

- **PROCESS ENGINEERS**
- **ASSEMBLY ENGINEERS**
- **WAFER FAB ENGINEERS**
- **ELECTRONIC TECHNICIANS**

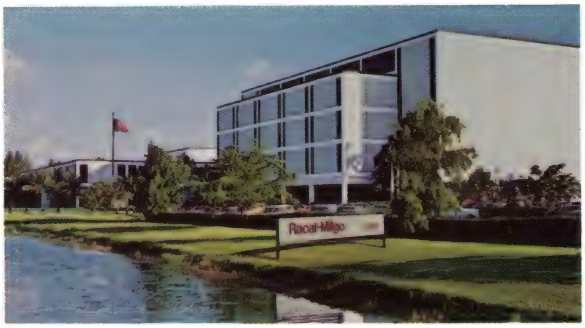
For immediate consideration concerning any of these positions, qualified candidates are invited to submit a detailed resume including salary history in confidence to:

Nancy Hughey
(Please refer to Section #26)
No agencies please.

14520 Aviation Blvd.
Lawndale, CA 90260

TRW **SEMICONDUCTORS**
Division of TRW Inc.
Encourage AA Candidates-EOE Employer

People have all kinds of reasons for moving to Florida.
We offer you a special reason.
Your career.



Florida is more than a place for growing oranges and suntans. Today, **careers** grow here, too. In a thriving electronics industry that we helped to build.

At our Miami headquarters, we design and build state-of-the-art data communications equipment. Our customers include many of the world's largest airlines, banks, government agencies, and more than half of the Fortune 500 companies. Dynamic applied research and development programs keep us right on the leading edge of data communications technology. We intend to stay there. That's why we're looking for the best people available.

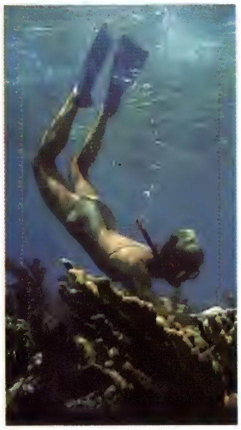
If you're experienced in communications hardware or software, we can offer you the perfect career combination—challenge, security, satisfaction, and reward. We have important openings at every level.

Send today for a copy of our "Opportunity Portfolio." You'll learn about building an exciting career (and discovering a special lifestyle)* with Racal-Milgo in Florida.

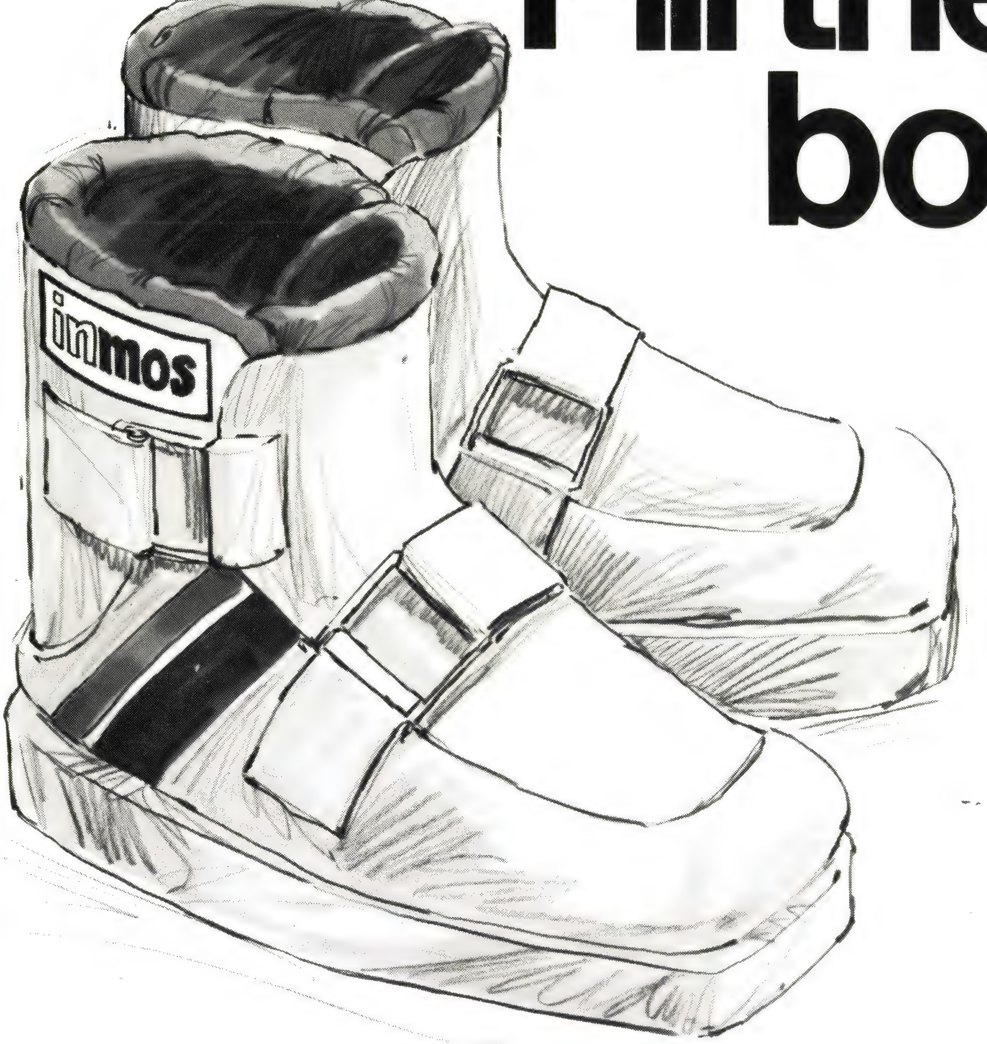
Racal-Milgo™

Employee Relations Department
Racal-Milgo, Inc.
8600 N.W. 41st Street, Miami, Florida 33166 Telephone (305) 592-8600

*All photographs shown are Racal-Milgo employees or their families.



Fill these boots



Stand inside these shoes for the downhill run. INMOS Corporation, a new semiconductor company, has established its U.S. operations in Colorado Springs in the heart of ski country. Our technology center is located in the shade of Pikes Peak in the Rocky Mountains where new fallen snow means a quick surface, fast runs and high views.

INMOS Corporation was founded by the pioneers in the semiconductor field, the people responsible for the breakthroughs that helped lead to the establishment of semiconductors as the growth industry of the decade. INMOS offers you the opportunity of following in the footsteps of the great thinkers of your field... working with the creative minds that will shape the future of the industry. We are a company dedicated to the research that will extend the frontiers of VLSI technology. Concentrating on the development of memory devices at a level of complexity of 50,000 to 100,000 transistors per chip, we are looking for the following innovative thinkers who are eager to follow the trail cut by great minds that will lead to the creative insights on which we will build our success.

Management

Facilities Manager
Manufacturing Manager
Product Engineering Manager

Engineering

Senior Product Engineer
Senior Memory Circuit Designers
CAD Engineers
Process Engineering Test Engineers
Packaging Development Engineer
Senior Applications Engineer
Wafer Process Engineer

Clamp on your bindings for a fast run to the future and send resume to Denny Grady, Personnel Administrator, Dept ED/2, INMOS Corporation, 2860 S. Circle Drive, Colorado Springs, Colorado 80906. *Or Call Collect (MST) 9AM-5PM, (303) 576-7130*

For employment opportunities in the UK, write to Michael Wright, INMOS Ltd., Whitefriars, Lewins Mead, Bristol, England.

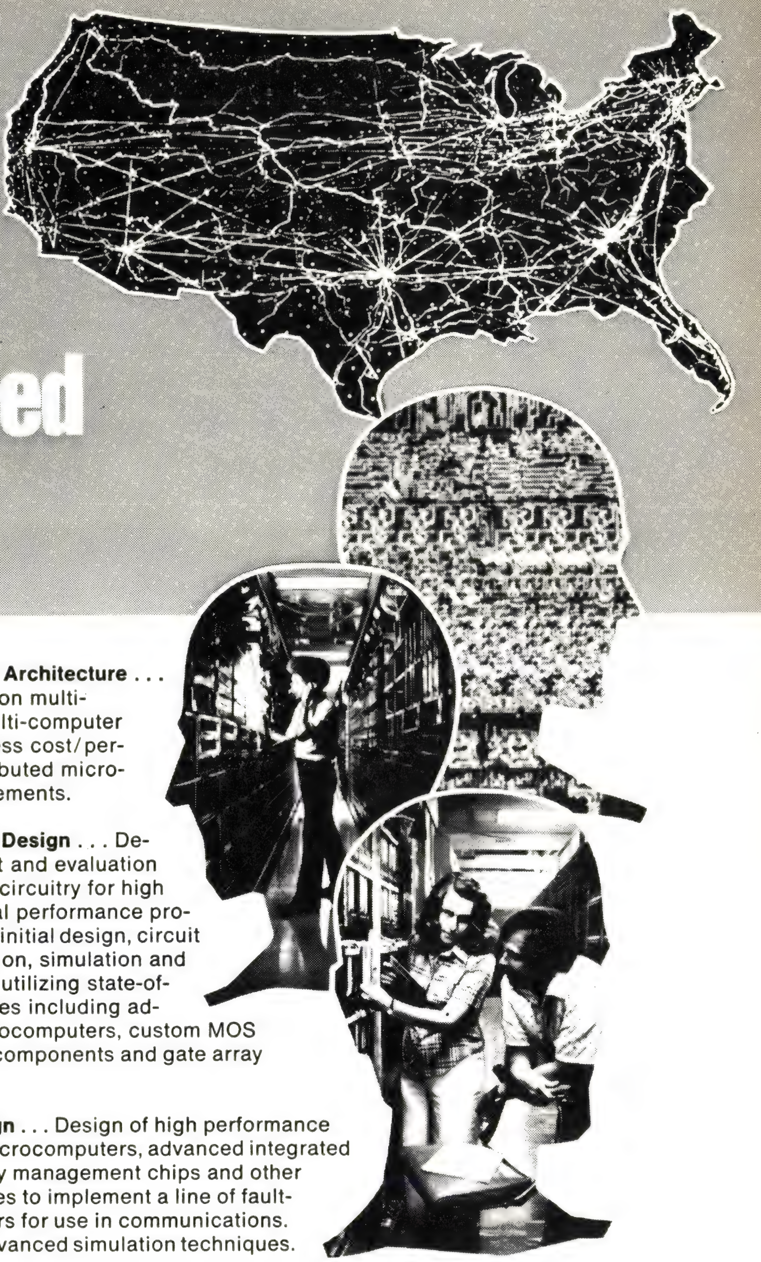
Honoring human resources in every respect... we are an equal opportunity employer M/F/H

inmos

We're building a great company. Together.

ENGINEERS & SCIENTISTS

Innovative minds find the resources and intellectual stimulation they need ...at Bell Labs



The record speaks for itself. Bell Labs engineers and scientists have pioneered many of the major technical breakthroughs that have reshaped the modern world. We continue to advance the state-of-the-art on many fronts: LSI technology, innovative microprocessor applications, new approaches to computer hardware, software and systems architecture, to name a few. In part this is due to the environment we provide professionals. The engineer is not isolated here, and has freedom to pursue intellectual interests.

We offer career-oriented engineers and scientists the opportunity to take on responsibility for developing new products, new services, new tools and techniques for operating and maintaining the Bell System and its national network efficiently and economically.

You'll find the latest in computer equipment here, excellent libraries, strong technical support, and highly developed educational programs. Most important, your work will stimulate your professional creativity, productivity and personal growth.

If you hold an advanced degree in Computer Science, Electrical Engineering or other discipline relevant to the exciting field of telecommunications, or strong experience in any of the areas of work described, we want to hear from you. We offer salaries and benefits that rank among the best in the industry. These opportunities are available at our facilities in **Colorado, Georgia, Illinois, Indiana, Massachusetts, New Jersey, Ohio and Pennsylvania.**

Computer System Architecture . . . Applied research on multiprocessor and multi-computer architecture. Assess cost/performance of distributed microprocessor arrangements.

Processor Circuit Design . . . Design, development and evaluation of central control circuitry for high availability general performance processors including initial design, circuit testability evaluation, simulation and analytical studies utilizing state-of-the-art technologies including advanced MOS microcomputers, custom MOS and bipolar VLSI components and gate array technologies.

VLSI Circuit Design . . . Design of high performance state-of-the-art microcomputers, advanced integrated processor memory management chips and other exploratory devices to implement a line of fault-tolerant processors for use in communications. Involves use of advanced simulation techniques.

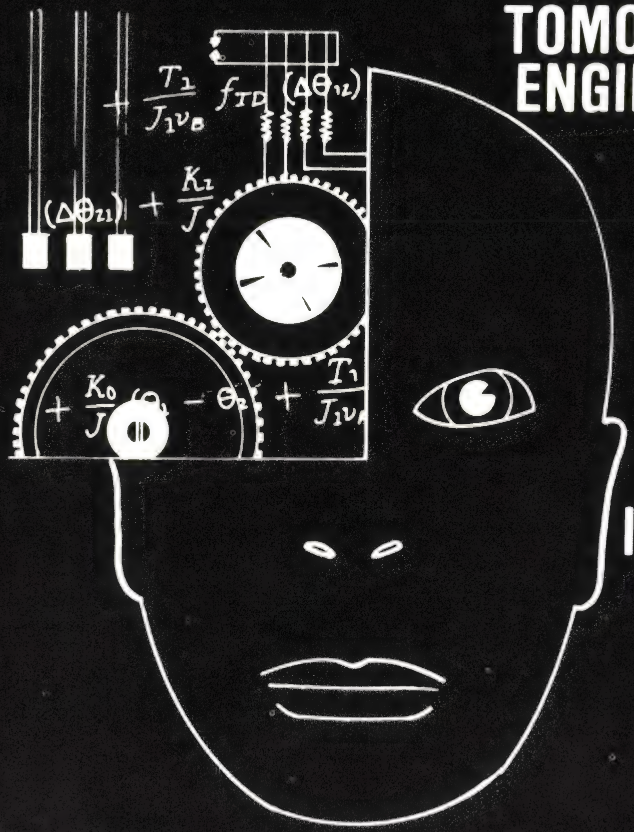
Computer System Design . . . Design and evaluation of a family of fault-tolerant processors ranging from low-end microprocessor/microcomputer based processors to advanced high performance microprogrammed machines providing full emulation capabilities. Processors as components of distributed systems are of special interest. Embraces conception through pilot model.

Digital Circuit Design . . . Design of processor boards and processor sub-systems for VLSI implementation. Familiarity with processor concepts such as memory management, data cache, pipelining, system bus, bus arbitration and CPU characteristics and operations.

To initiate your prospective employment, please indicate your interest in investigating a future with Bell Labs. Write to us stating your area of preferred specialization and geographic location. Include a resume and transcript. Direct it to: Director of Technical Employment, Bell Laboratories,
Center 831-145, 600 Mountain Avenue,
Murray Hill, N.J. 07974

Bell Laboratories

An Equal Opportunity Employer



IMAGINE TOMORROW'S ENGINEERING

GOULD IS THERE TODAY!

Our engineers designed, manufactured and delivered the Mk48 torpedo ... on time and under budget! We are currently applying our total systems responsibility concept to many challenging defense systems programs both above and below water. This will assure the United States superiority into the 1980's. Our rapid expansion has created openings for U.S. Citizens experienced in the areas below.

- STATISTICS/MODELING
- DTC/LCC
- INFRARED
- ACOUSTICS
- FIBER OPTICS
- SYSTEMS INTEGRATION
- OPERATIONS ANALYSIS
- COMPONENTS
- AERO-HYDRO DYNAMICS
- STRUCTURED SOFTWARE
- COMPUTER ARCHITECTURE
- RELIABILITY
- SIGNAL & DATA PROCESSING
- WARHEAD SYSTEMS
- TEST & EVALUATION
- NON-METALLIC MATERIALS
- SAFETY & HUMAN FACTORS
- ELECTRO/MECHANICAL DESIGN

We will offer you an excellent salary, complete benefits and the advancement potential you would expect from a rapidly growing Fortune 200 company.

For further information send letter of inquiry and/or resume to:

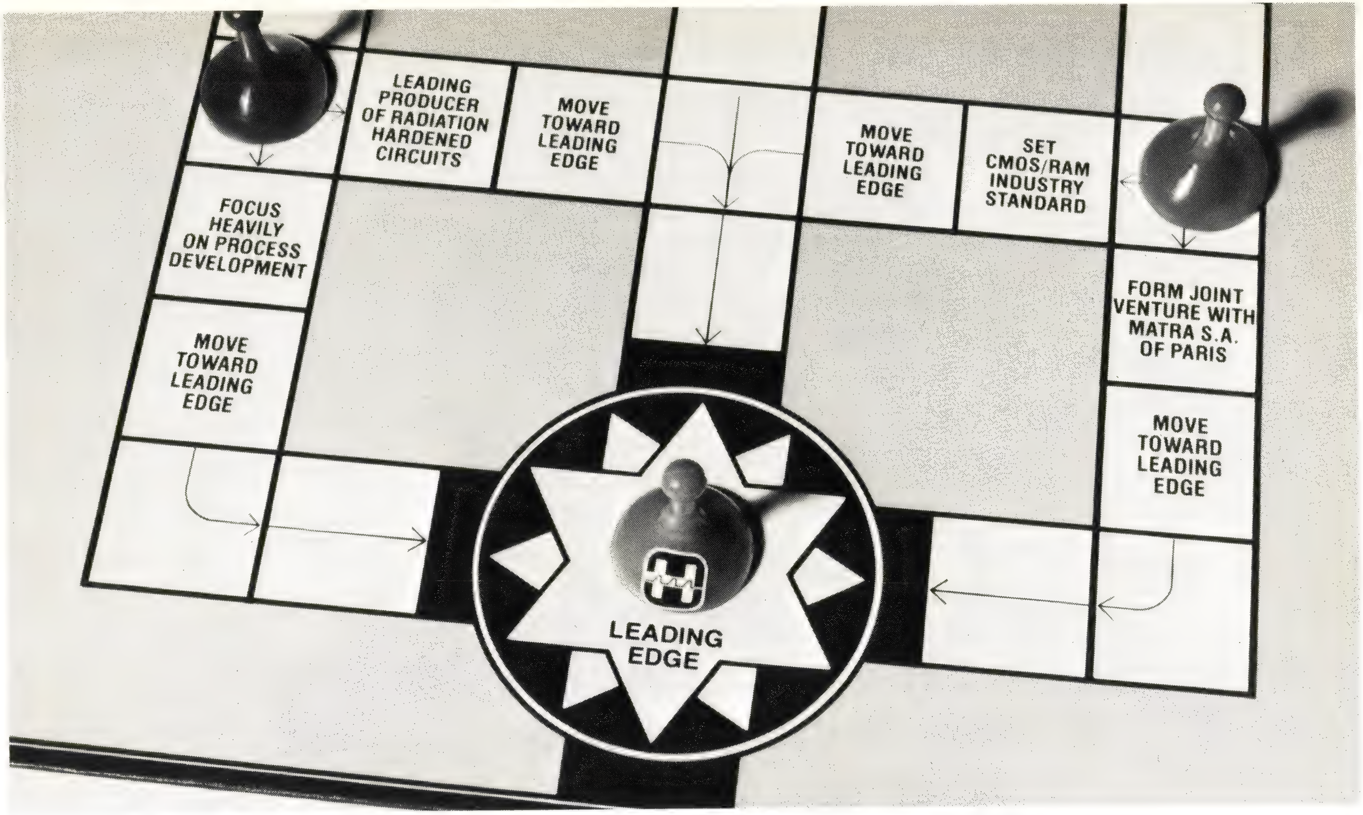
Kathy A. Shook
Gould Ocean Systems Division
P.O. Box 17044
Euclid, Ohio 44117
or call Collect: 216-486-8300 Ext. 313

An Equal Opportunity Employer M/F/H

GOULD

Big ads equal big savings

The regular or ROP rate for Electronic Design's full page black and white unit is 23% greater than the *special rate for* recruitment advertising. By using a full page, advertisers get important positioning, frequent domination of the spread — and significant cash savings. Small-space classified display ads are a bargain, too, but nothing can match *full* pages for *full* impact.


LEADING PRODUCER OF RADIATION HARDENED CIRCUITS
MOVE TOWARD LEADING EDGE
MOVE TOWARD LEADING EDGE
SET CMOS/RAM INDUSTRY STANDARD
FOCUS HEAVILY ON PROCESS DEVELOPMENT
FORM JOINT VENTURE WITH MATRA S.A. OF PARIS
MOVE TOWARD LEADING EDGE
MOVE TOWARD LEADING EDGE
LEADING EDGE

THE I.C. GAME. IT'S ZERO PERCENT LUCK.

It's hard work leading an industry.

It's challenging.

It's state-of-the-art.

It's what we do at Harris Semiconductor. No luck about it.

Harris Semiconductor supplies both industrial and governmental markets with a wide range of standard and custom IC's.

We design, develop, and manufacture linear, data acquisition, digital logic, microprocessor and memory integrated circuits.

We have the industry's most advanced CMOS production facility.

And the obvious advantage of combining design, development, production, and management under one roof.

Our enviable record of growth has created the need for innovative, talented semiconductor professionals to join our group of exceptionally talented people.

☐ Digital Circuit Designers ☐ Analog Circuit Designers ☐ Process Engineers ☐ Product Marketing Engineers ☐ Software Engineers ☐ Applications Engineers ☐ Advanced Products Logic Planning Engineers ☐ Mask Designers ☐ Test Engineers (Fairchild/Sentry Equipment) ☐ Production Supervisors ☐ Production Control Supervisors.

Add it all up.

A professional environment that encourages and rewards contribution.

A lifestyle on Florida's Atlantic Coast.

A commitment to technology that's 100% state-of-the-art.

When you think of your future, think of Harris Semiconductor.

Send resume with salary history to: Ken Judson, Professional Staffing Supervisor, Harris Semiconductor, P.O. Box 883, Dept. 168, Melbourne, Florida 32901. Or call collect (305) 724-7782.

HARRIS
SEMICONDUCTOR GROUP

The leading edge in technology—The last word in IC's.

An Equal Opportunity Employer M/F

For tomorrow-minded Electronics Engineers.

A new world of opportunity in Microelectronics with Martin Marietta Aerospace, Orlando Division.

By "new" we mean a multi-million dollar investment in new facilities, equipment and staff expansion, that's vital to the development and production of our future aerospace products; electronic, tactical missile and fire control systems.

We've done this to maintain our lead in thick film hybrid circuitry, as well as other new technologies we're working on, such as: CCD, GaAs integrated circuits, VLSI and detector arrays.

Lifestyle? Orlando, Florida, has more than its share of advantages. Like easy access to the Atlantic and Gulf shores. Good schools. 2,000 nearby lakes to fish and explore. And an affordable cost of living by today's standards.

Our Microelectronics & Components Group is expanding, and we're looking for engineers to fill the following positions:

Senior Hybrid Design Engineers

Requires a BSEE and at least 2 years' experience in thick film hybrid design. Responsibilities include the design, analysis and product engineering of complex high reliability hybrid circuits used in military weapons systems.

Senior Component Engineers

Requires a BSEE and at least 2 years' experience with components and materials used in thick film hybrid microcircuits. Responsibilities include specification development, vendor interface and support of failure analysis efforts.

For further information, please fill out and mail the coupon below...or send your resume in strict confidence to: Dr. David Meyer, Deputy Director Microelectronics, Martin Marietta Aerospace, P.O. Box 5837, Orlando, Florida 32855. Attn. MP #189 ED3180.

Dr. David Meyer, Deputy Director Microelectronics,
Martin Marietta Aerospace, P.O. Box 5837,
Orlando, Florida 32855. Attn: MP #189 (ED3180)

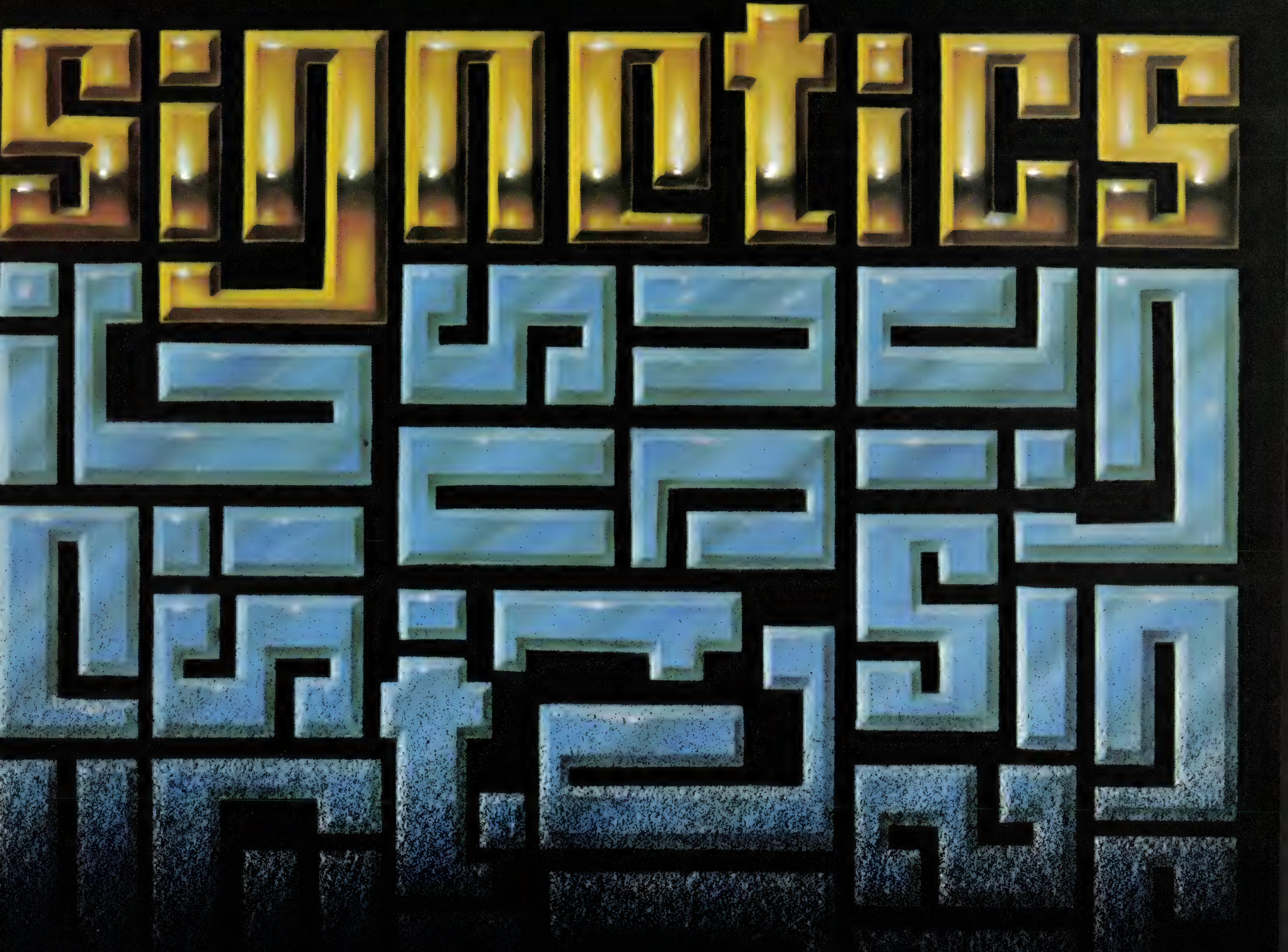
Please contact me regarding your Microelectronic & Component Engineering opportunities with Martin Marietta Aerospace in Orlando, Florida.

Name______________________________
Address______________________________
City________________State________Zip______
Home Phone ____________________________
Engineering Degree ________________________
Salary Required __________________________
Employer ______________________________
Short Summary of Your Engineering Duties ____________

This information will be held in strict confidence.

We are an equal opportunty employer, m/f/h.

MARTIN MARIETTA



**Rewards. Sound Management.
Credibility. Respect. Growth. Direction.**

Without a doubt, you've heard these words plenty of times. Some people call them "buzz" words because they're supposed to draw your attention.

At Signetics, we do more than simply attract you with impressive sounding words.

We make them come to life.

If that's what you want, you want us.

We're setting the pace for the '80s in the semiconductor industry.

Send us your resume.

Signetics, MS 900, 811 E. Arques
Avenue, Sunnyvale, CA 94086.
(408) 739-7700.

We are an equal opportunity employer m/f.

The Good People Company.

signetics

a subsidiary of U.S. Philips Corporation

Semiconductor Engineers:

Now you can have a part in developing tomorrow's computer technology.

If you already have an impressive record of achievement in LSI technology, and you'd like to broaden your horizons, Digital has an outstanding opportunity for you.

We're looking for dedicated professionals who can make significant contributions to our state-of-the-art semiconductor development projects. You'll be working closely with Computer Design Engineering in a dynamic, unstructured environment -- combining your ideas and expertise with those of people in other areas to create new computer breakthroughs.

We know that many of the people we want probably aren't even looking for a job. But if you're talented and the thought of pursuing professional and personal goals with a highly sucessful company appeals to you, you should know that Digital is the place where you can grow and use your abilities to their full potential.

Right now, we have positions available for qualified and experienced:

MOS Circuit Design Engineers
Bipolar Circuit Design Engineers
Process Development/Device Engineers
CAD Software Engineers
Logic Design Engineers
Process Engineers
Product Engineers

San Francisco Interviews:
February 12, 13, 14 and 15

Members of Digital's Microproduct Development Group will be available for interviews in San Francisco, February 12, 13, 14 and 15. To arrange an appointment, call Rick Wacholz COLLECT at (617) 366-8981 ext. 509, Monday - Friday 9-5 EST; or send him your resume at Digital Equipment Corp., Dept. G215 3842, 165 Flanders Rd., Westboro, MA 01532. Please state that you would like to arrange an appointment in San Francisco.

If you are interested, but unable to meet with us at this time, you are also invited to forward your resume to Rick Wacholz to arrange an appointment at another time. We are an equal opportunity employer m/f.

digital

DESIGN ENGINEERS

We're Looking for People Who Are Looking for a Challenge!

VITRO Laboratories is looking for people who are looking for a challenge. Our expanding programs have created immediate long-term career openings for **Digital Electronic Design Engineers.** The necessary qualifications include a BS in Engineering and 3 to 5 years of circuit design experience, as well as design experience on 8-bit microprocessors and support circuits. You should also be familiar with HTL, CMOS, and T2L Logic families, and knowledgeable in high level and assembly language programming, and have experience with microprocessor development systems.

If you would like to become part of a progressively managed organization that offers professional growth and a complete benefit program, including relocation assistance to those eligible, **contact Doug Bushey, TOLL FREE at (800) 638-2901, ext. 2105, or send your resume and salary requirements to:**

AUTOMATION INDUSTRIES, INC.
VITRO Laboratories Division
14000 Georgia Avenue,
Silver Spring, Maryland 20910

An Equal Opportunity Employer M/F/H
U.S. Citizenship Required

If you currently earn between $22,000 and $48,000 we've got a better job for you...NOW!

Every day you spend in the wrong job is a waste of time, money and talent...YOURS! Your talents and experience are in great demand and you can choose among many rewarding opportunities available in your field. But how?

Talk to the experts at Wallach. We've been successfully recruiting professionals like yourself for over 15 years.

Nationwide opportunities include technical/management consulting, project management, R&D, test and systems evaluation in the fields of Communications, Satellites, Weapons, Intelligence, Computer, Energy, and Aerospace systems. Specific skill areas include:

- **Minicomputers**
- **Microprocessors**
- **Software development**
- **Signal processing**
- **Digital systems**
- **Command & Control**
- **Radar Systems**
- **Communication Systems**
- **EW/SIGINT/ELINT**
- **Microwave Systems**
- **Electromagnetics**
- **Fire Control Systems**

Don't waste another day in the wrong job! Call Robert Beach collect at (301) 762-1100 or send your resume in confidence. We can find you a better job. Let us prove it to you...NOW!

WALLACH...Your career connection

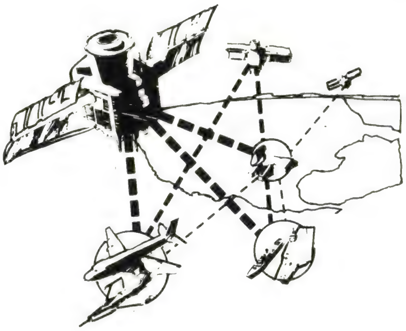
Equal Opportunity Employer Agcy.

WALLACH
associates, inc.

1010 Rockville Pike
Box 6016
Rockville, Maryland 20852
(301) 762-1100

Join the leader...

Join the people who are revolutionizing the Navigation and Communication systems of the world.



Today Magnavox Advanced Products Division is playing a key role in the most revolutionary advances in the history of navigation and position determination.

This represents an enormous advance for both military and commercial positioning worldwide. It is made possible by the successful merging of satellite based navigation and communication technologies; fields in which Magnavox exercises undisputed leadership!

Magnavox Advanced Products Division is organized into three product directorates:

Global Positioning System

With the development of the NAVSTAR Global Positioning System — GPS — man will be able to fix the position, velocity, and time anywhere on earth, with unprecedented accuracy.

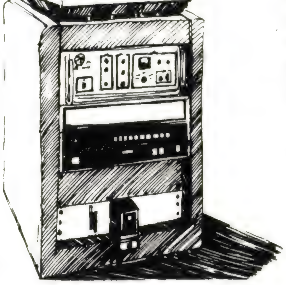
As development progresses, this system will replace the radio navigation systems currently in use. Current applications at MAGNAVOX range from man-packs to satellite sets for space application.

The Full Scale Engineering development of User Equipment for NAVSTAR-GPS is your opportunity to join a very successful electronics team in an environment conducive to your professional growth. Current career opportunities exist for:

Navigation Systems Analysts
Senior Systems Test Engineers
RF Design Engineers
Mechanical Systems Designers
Communications Systems Analysts
Packaging Design Engineers
Program Engineers
System Test and Integration

Communications Systems

We are developing, manufacturing, marketing, and supporting some of the most sophisticated communications systems ever conceived for the United States Government. MAGNAVOX's communications business applies advanced digital communications techniques, including: pseudo noise, spread spectrum anti-jam modulation to communications systems, both tactical and strategic.

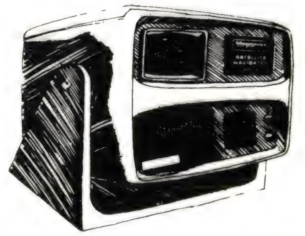


To continue development in this area, our Communications Systems Operation requires high caliber engineers. Current career opportunities exist for:

Communications Engineers
Communication Systems Analysts
Program Managers
System Test and Integration

Marine Systems

This area encompasses the development, production, sale and support of marine electronic products and systems to commercial and government interests. Our continuing research and development programs are producing the most sophisticated navigation and communications systems in the world.



Because of our commercial, industrial orientation, development is not controlled by large government contracts. Our engineers and programmers work in small, cohesive units which have team responsibility for new designs and their production.

The MAGNAVOX Marine Systems Operation is a strong, growing and technically sophisticated group. To support these activities, we need talented, hard working professionals in the following areas:

Digital Designers
Firmware Designers
Analog Circuit Designers
Software Engineers

If you're seeking a career where there's a diversity of technological challenges, complete involvement with projects from concept through production, a strong management team, career stability, and a stimulating environment, Join the Leader . . . MAGNAVOX.

You are invited to send your resume to:

Professional Placement
Dept. ED-215
2829 Maricopa Street
Torrance, CA 90503

We are an equal opportunity employer and encourage women, minorities and handicapped to apply.

Magnavox
Government and Industrial Electronics Company
Advanced Products Division

ADVANCING TECHNOLOGY

Embracing the past
To insure the future

During the eighth to eleventh century A.D. the SHIELD, a massive (up to 200 pounds and 2½ feet in diameter) circular instrument made of tempered metal and hard woods provided more than ample protection in the hands of a highly skilled Viking.

In the twentieth century Northrop professional engineers are advancing the state-of-the-art technology in design and development of protective electronic countermeasures instrumentation. In our quest for excellence, we are seeking individuals imbued with the spirit of yesterday who are prepared to enhance the technology of tomorrow.

PRODUCT DESIGN
SENIOR ENGINEERS•PROJECT ENGINEERS•MICROWAVE

SOFTWARE
ENGINEERS•ANALYSTS PROGRAMMERS

SYSTEMS
SENIOR ENGINEERS•PROJECT ENGINEERS•MICROWAVE

AUTOMATIC TEST ENGINEERS
DIGITAL TEST•ANALOG TEST RF(MICROWAVE TEST)

Northrop is meeting the challenges of the future with some of the best engineering talent in the nation. People with initiative and creative know-how. If you would enjoy unparalleled potential for growth, outstanding salaries and benefits, Join us! Forward your resume to PROFESSIONAL EMPLOYMENT MANAGER, DEPT. ED/214.

NORTHROP CORPORATION
DEFENSE SYSTEMS DIVISION
600 Hicks Road, Rolling Meadows, IL 60008
As an equal opportunity employer, we encourage minorities and females to apply.

We Respond To All Inquiries.

NORTHROP

Principal Engineer-M.S.E.E.

Quite simply, this may be the best career opportunity you'll ever get.

GenRad, a leader in Automatic Test Equipment, is looking for a Principal Engineer to participate in the design and development of our new products. You should have expertise in ECL design, high speed driver/sensor technology, high speed clocks, and microprocessors. An M.S.E.E. and a minimum of 8-10 year's experience working with digital IC testers are also necessary.

You must have the ambition and know-how to design the kind of products that have made us the number one company in the field. You'll work hard, too, because GenRad is the fastest growing company in the industry, and we intend to keep it that way.

As Principal Engineer at GenRad, you'll be in one of the top engineering positions in the company. You'll receive an excellent salary, comprehensive benefits, and a generous stock purchase plan.

If you are interested, send your resume to Joan Sawyer, GenRad, Inc., 300 Baker Ave., Concord MA 01742; or call her at (617) 369-4400, ext. 2329.

GenRad

Put our leadership to the test.
The world's leading manufacturer of automatic circuit board test systems, and an important supplier of equipment for component testing and acoustic and vibration analysis.

An equal opportunity employer M/F.

ELECTRONIC ENGINEER (Design)

The Lister Hill National Center for Biomedical Communications has a career Civil Service position in their Communications Engineering Branch for a Design Engineer at the GS-13 level. Salary ranges from $29,375 to $34,270 per annum.

Background required in the design and development of audio and video communication systems. Candidates should have experience in the design of analog and digital communications circuits and subsystems for audio, video and data.

Send resume or SF-171 by March 31, 1980, to: Personnel Officer.

National Library of Medicine

NATIONAL INSTITUTES of HEALTH
8600 Rockville Pike
Bethesda, MD 20209

Equal Opportunity Employer

THE JOB IS TODAY... THE PLACE IS TOMORROW... THE FUTURE IS NORTHROP ELECTRONICS!

In the next ten years, Northrop Electronics will make tremendous advances, traveling beyond our industry's present level.

We invite you to be part of these advances.

You will be working with people who have a record of pioneering innovations. For example, Northrop Electronics developed the first daytime star tracker, the first stellar-inertial guidance system, the first airborne solid state digital computer and the first floating ball inertial measurement unit.

Our newest project is the Advanced Inertial Reference Sphere. The U.S. Air Force has selected us to develop this system for the guidance of Missile X.

If you are an engineer or scientist geared for upward mobility and want your chance to advance our technology to an even higher state-of-the-art, find out more about Northrop Electronics.

We need people with strong analytical backgrounds for test analysis and modeling of missile guidance systems. Work involves planning tests, designing data processing and analysis procedures, and performing analysis.

Take a look at the list of some of our other career opportunities below.

DESIGN ENGINEERING
- Analog Test Equipment Design
- Precision Mechanical Design
- Materials & Process Engineering
- Electro-Mechanical Design/Airborne Equipment
- Ground Support & Factory Checkout Equipment Design
- Documentation Engineering
- Design-Automated Graphics
- Environmental Analysis-Thermal & Climatic
- Structural Analysis
- Hydraulics Engineering
- Component & Standards Engineering

AUTOMATED TEST SYSTEMS
- Software Design
- Software Requirements & Maintenance Programming
- Integrated Test Design
- Test Procedure Development

TEST AND FACTORY SUPPORT EQUIPMENT ENGINEERING
- System Level Test Planning
- Systems Test Conductor
- Systems Diagnostics, Analysis
- Project Engineering
- Analog/Digital Test Equipment Design

INDUSTRIAL & MANUFACTURING ENGINEERING
- Work Measurement Systems
- Tooling Design & Development
- Cost Estimation & Control
- Trade Studies
- Operational Analysis
- Requirements Analysis

DIAGNOSTIC SYSTEM ENGINEERING
- Microprocessor Software 8080 Class
- System Formulation/Turbojet Engine Monitoring
- Analog Circuit Development
- Packaging—High Density Circuit Board

RELIABILITY ENGINEERING
- Failure Analysis/Corrective Action
  - Passive Electronic Devices
  - Contact Systems
  - Semiconductor Devices
  - Magnetic Devices
  - Hybrid Micro-Circuits—Thick & Thin Film
- Stress Analysis
- Design Review
- Corrosion Prevention & Control
- Specification Development
- Hardened Micro-Circuits

INFORMATION SYSTEMS ENGINEERING
- Programming—Intelligence Systems
- Digital Image Systems
- Software Applications—Microcomputers 8080-86 Class

SYSTEMS ENGINEERING
- Inertial Navigation Analysis Simulation Studies Calibration & Alignment
- Requirements Analysis
- Software Engineering and Design
- Test Design & Planning
- Test Data Analysis
- Evaluation Studies

DEVELOPMENT ENGINEERING
- Circuit Analysis/Linear/Digital
- Radiation Effects Analysis
- Nuclear Radiation Test
- SYSCAP or TRAC Circuit Analysis
- Test Requirements—Analog & Digital Circuits
- Fault Isolation
- Analog & Digital Circuit Design & Development
- Power Amplifiers-Semiconductor, AC-DC converters, P.S. and test equipment

If you'd like more information, or for immediate consideration, send your resume in complete confidence to:

L. Amos • 2301 West 120th Street • Hawthorne, California 90250

ELECTRONICS DIVISION
NORTHROP
Making Advanced Technology Work.

U.S. Citizenship or Permanent Visa Required

An Equal Opportunity Employer M/F/H

ENGINEERING

LSI/VLSI Professional Opportunities

At NCR Microelectronics you'll be part of a far-sighted R&D enterprise.

If you like being involved in long range state-of-the-art investigations as well as designs of custom chips for specific requirements, here is an opportunity to join a creative R&D organization that has NCR's powerful resources behind it.

At NCR Microelectronics in Miamisburg, Ohio, much of the work we are doing in memories and microprocessor capabilities is exploratory in nature. Still, we have been manufacturing MOS semiconductors for NCR's needs for many years. Our well developed processing capability is unsurpassed. We are a leader in LSI design, non-volatile memory technique and deeply involved in VLSI development. All of this to help create the most cost-effective, computerized systems for NCR's world market.

We are expanding. We have immediate growth and promotion-created openings at all levels for engineers and scientists with BS/MS/PhD degrees in Electrical Engineering, Solid State Physics, or other compatible professional engineering disciplines. Your professional efforts can be extended in Advanced Development, Process Development or Engineering. Memory and Systems Design as well as Circuit Design and QA engineering. Salaries are fully commensurate with related experience. Benefits, including relocation assistance to one of the most attractive and affordable areas of the midwest, are what you would expect from the world's second largest computer company.

If you have the qualifications we are looking for and you are a permanent resident or citizen of the United States, then let's explore for mutual interest. Send your resume to: Mr. T. F. Wade, NCR Microelectronics, Dept H74, 8181 Byers Road, Miamisburg, Ohio 45342.

NCR

Complete Computer Systems

An Equal Opportunity Employer

REACH THEM WHERE THEY READ

Electronics engineers and engineering managers are a special breed. They are extremely loyal to their favorite technical magazines, and *Electronic Design* is their best read favorite—by far. It's the ideal platform for your recruitment message.

special late close

Recruitment advertisers have special "late close" priveleges in *Electronic Design.* Each issue closes only 14 days before mailing date. Don't get lost in general newspapers . . . go where you'll find *experienced* engineers ... You'll find them reading *Electronic Design!*

TODAY MAY BE THE BEST TIME TO MAKE YOUR CAREER MOVE

But first make sure your new employer measures up.

With all of those prospective employers trying to attract your engineering skills, now is the best time to look beyond "just a job" and consider your career. Your real objective is to find the perfect combination—challenge, satisfaction, security, and reward. To assist you, we've prepared a checklist of points to consider when you're evaluating a new employment possibility. It's a good way to compare the companies seeking your expertise.

Career Opportunity Checklist for Engineers

INDUSTRY GROWTH AND STABILITY

No one wants to be "phased out," so check for security: **YES ? NO**

Is the company part of an industry that's vital, growing, dynamic? ☐ ☐ ☐
Will the growth continue throughout the 1980s and beyond? ☐ ☐ ☐

COMPANY HISTORY AND REPUTATION

You can tell a lot about a firm by its track record:

Is the company recognized and respected in the industry? ☐ ☐ ☐
Have sales and profits increased at a steady rate? ☐ ☐ ☐
Is it known for its technological innovations? ☐ ☐ ☐
Are its employees motivated and well rewarded? ☐ ☐ ☐
Does the company seek technological employees on a permanent, ongoing basis? ☐ ☐ ☐

WORKING CONDITIONS AND ENVIRONMENT

Look for good people, team spirit, and top-notch facilities:

Is the atmosphere one of loyalty, pride, and achievement? ☐ ☐ ☐
Do employees welcome the challenge of difficult assignments? ☐ ☐ ☐
Are creativity and independent thinking encouraged? ☐ ☐ ☐
Are the company's engineering goals clear-cut and attainable? ☐ ☐ ☐

THE COMPANY LOCATION

Relocation is a big professional and personal commitment.

Is the company located in an existing or emerging electronics center? ☐ ☐ ☐
Are there major universities and other technological resources nearby? ☐ ☐ ☐
Will the company assist me in relocating? ☐ ☐ ☐
Can I provide my family a comfortable lifestyle in this area? ☐ ☐ ☐
Are there cultural and entertainment opportunities? ☐ ☐ ☐
Is there a variety of recreational and leisuretime activities? ☐ ☐ ☐
Are the climate and surroundings pleasant? ☐ ☐ ☐

PERSONAL AND PROFESSIONAL GROWTH

Job satisfaction means more than just a paycheck:

Does the company give full recognition to the engineering role? ☐ ☐ ☐
Will I be working and interacting with other talented professionals in my field? ☐ ☐ ☐
Will my accomplishments be acknowledged, appreciated, rewarded? ☐ ☐ ☐
Will I be encouraged to seek more challenge and responsibility? ☐ ☐ ☐
Will the company pay for advanced training in technology and management? ☐ ☐ ☐
Can I pursue my own career goals within the company framework? ☐ ☐ ☐

THE LONG RANGE PICTURE

Where will you be professionally in 5 years?...in 10 years?

Are there plenty of opportunities for rapid advancement within the company? ☐ ☐ ☐
Does the company encourage engineers to assume positions of authority? ☐ ☐ ☐
Will I be allowed to move into those engineering areas that interest me most? ☐ ☐ ☐
Can I choose my own career path—into technological leadership or executive management? ☐ ☐ ☐

One Company to Evaluate

At Racal-Milgo, we're looking for capable communications hardware and software people to join our engineering team. Our success has created needs at every level, from entry to top management. We have a lot to offer you.

The mainstream of our business is data communications—where today's action is. We're a pioneer, and a recognized leader in the field. Our state-of-the-art product lines include modems, multiplexers, data encryption, and systems for sophisticated network control and performance assessment.

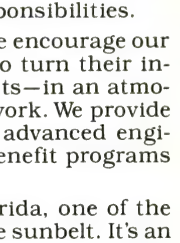
We're proud of our growth—$64 million in sales two years ago, $80 million last year, and over $100 million this year—and we're still growing. Applied research and technology keep us on the leading edge in data communications; our engineers face some of the industry's most challenging (and rewarding) responsibilities.

Racal-Milgo is a great place to work. We encourage our technical people to think creatively, to turn their innovative ideas into successful products—in an atmosphere of friendly, professional teamwork. We provide them with one of the nation's most advanced engineering facilities. Our salaries and benefit programs are among the best in the business.

We're located in suburban South Florida, one of the growing new electronics centers in the sunbelt. It's an international area, gateway to Latin America, blessed with a pleasant climate year-round. There are excellent cultural and entertainment opportunities, plus swimming, diving, boating, sport fishing, golf, tennis, and all the other benefits of a cosmopolitan resort. There's a wide choice of employee clubs to introduce you and your family to new activities. And if you're interested in furthering your professional or business related education, we'll pay for your coursework at any of the major universities nearby.

At Racal-Milgo, we're experiencing dynamic growth, and we need good people at all levels. The working conditions are excellent...advancement and rewards come fast...and our new two-track career program lets you decide whether to rise to the top on the technical side or to move into management. (Our president and board chairman are both EE's.)

We're looking for the best. If you are too, let's get together. I hope to personally welcome you aboard. Send me your resume today; no letter required. You'll receive a prompt reply.



Ed Hilpert

Ed Hilpert
Vice-President, Engineering

Racal-Milgo™

Racal-Milgo, Inc.
8600 N.W. 41st Street Miami, Fl. 33166

MB
ELECTRONICS
MILTON BRADLEY

ATTENTION ALL CREATIVE HARDWARE/SOFTWARE ELECTRONIC ENGINEERS

The Milton Bradley Company, located in Springfield, MA, the home of Simon, Big Trak, Microvision, Comp IV and a host of other highly successful electronic games and toys, is seeking to fill, due to dramatic growth, a number of exciting electronic product development positions. If you are one of those individuals who either in your current position or in your wildest dreams, has contemplated the desire to utilize your professional and technical knowledge in a game and toy oriented environment, we ask that you seriously consider the Milton Bradley Company and the exciting openings described below:

ELECTRONIC PRODUCT DEVELOPMENT HARDWARE ENGINEERING

Senior Project Engineer

The successful candidate for this position will have a BSEE and MSEE with a minimum of 10 years experience in hardware electronic product engineering preferably in a consumer goods environment.

Manager Electronic Design Packaging

The successful candidate for this opening will have a BSME with 10 years mechanical design in a high volume consumer goods electronics with a current working knowledge of micro-electronic packaging techniques. This should include an understanding of chip and wire bonding directly to PC boards.

Electronic Development Engineer

This position requires a BSEE and 3-5 years experience in electronic consumer product development.

ADVANCED ELECTRONIC RESEARCH

Senior Project Engineer

This position requires a highly conceptual electronic product development engineer who possesses a BSEE, MSEE, or the equivalent degrees in computer science. Experience and knowledge of both micro-electronic hardware and software is essential. This key slot functions in a highly creative and forward looking atmosphere.

Project Engineer

The incumbent in this position will possess a BSEE or equivalent thereof and will have had experience in a highly conceptual electronic consumer goods environment. 3-5 years experience is desirable.

The Milton Bradley Company, as indicated above, is located in suburban Springfield, MA in the heart of the Berkshire Hills. The quality of life in this area is extremely high. The area offers significant advantages in terms of recreational, cultural, social and academic pursuits.

If you feel you have both the necessary qualifications and interest in any of the above positions, please submit your resume and salary history in confidence to:

MB
MILTON
BRADLEY

Director of Professional Recruiting
Milton Bradley Company
P.O. Box 288
Springfield, MA 01101

An Equal Opportunity Employer

---

have a gripe?

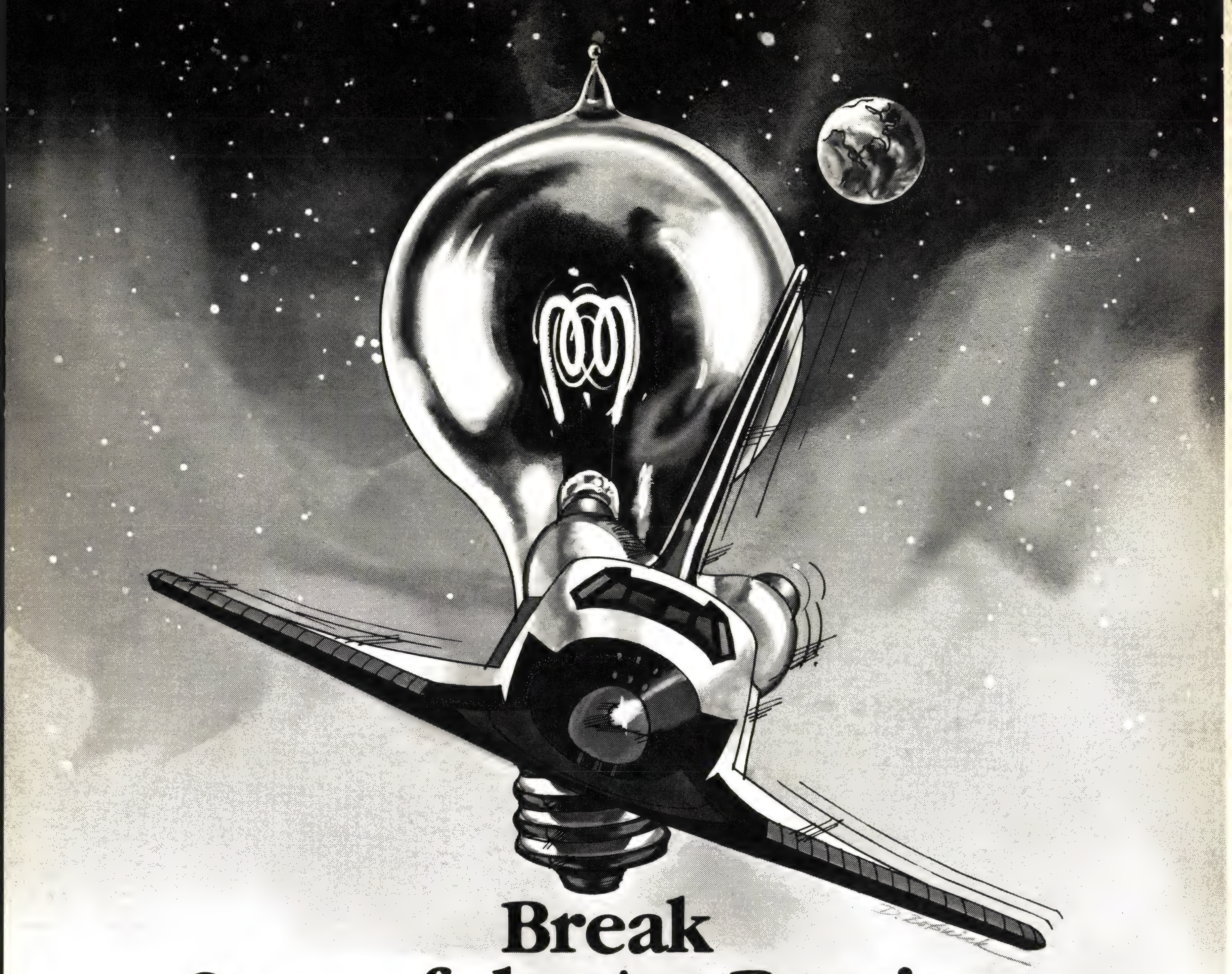
let us know about it!

We'll help you put pressure on any company that makes promises in its ads ... then fails to deliver.

Electronic Design refuses to run advertisements deemed to be misleading or fraudulent.

ACCURACY is everybody's business. So if you have a gripe about a misstatement or inaccuracy in either editorial or advertising material in *Electronic Design* ... tell us about it. We'll do everything we can to find out what happened and see that it's corrected. Notify ...

Lucinda Mattera
Editor
Electronic Design
50 Essex Street
Rochelle Park, New Jersey 07662



Break State of the Art Barriers with GE Re-Entry Systems Division

That's what working at GE is all about. From the first barrier-breaking light bulb by Edison. To today's barrier-breaking re-entry systems. With history-making, Nobel Prize winning scientists in-between.

At GE's Re-Entry Systems Division in Philadelphia, you'll work with the finest state of the art engineers.

You'll have all the freedom and responsibility you'd like. Plenty of room to move up. Excellent training. Tuition refunds. A better-than-competitive compensation/benefit package. And you'll live and work in the diverse and interesting environment of historic Philadelphia.

If your kind of engineering genius breaks barriers, we know you're in demand. Give us a chance to make history together. Call (215) 823-2001, or send your resume to Pat Erceg, General Electric Re-Entry Systems Division, 3198 Chestnut St., Philadelphia, Pa., 19101.

GENERAL ELECTRIC

Equal Opportunity Employer M/F

LSI AND CIRCUIT ENGINEERS

The future is in Systems

At Honeywell's Small/Medium Information Systems Division (S/MISD), we are expanding our advanced state-of-the-art design center to focus on the future of our overwhelmingly successful minicomputer and terminal products. We're looking for experienced LSI and Circuit Engineers to join us.

- **LSI Circuit/ Logic Design**
- **LSI Computer Architect**
- **LSI Testability Design**
- **Circuit Application**

Working in a select group determining the key technology innovations for our next generation products, you will be involved in conceptual and architectural design of central processor and controller LSI. Your talents are needed to perform logic partitioning, device, circuit and layout design using our state-of-the-art Calma interactive graphics system.

Opportunities also exist in logic design for maximum testability and circuit application engineering with special emphasis on high speed interconnection techniques.

Interested candidates should CALL COLLECT or write:

Jerry R. Haynesworth
HONEYWELL S/MISD
300 Concord Road
Billerica, Massachusetts 01821
(617) 671-2894

An Equal Opportunity Employer M/F

Honeywell

People,
Our Competitive
Edge

ENGINEERING

SAN DIEGO, CALIFORNIA

Exciting career opportunity for Professional Engineers with experience in digital signal processing and analog circuit and systems design. SPECTRAL DYNAMICS is growing and has the following immediate requirements.

SENIOR DESIGN SPECIALIST

Prefer PhD in Electrical Engineering, Mathematics, Physics or equivalent. Will provide predesign guidance and design concepts for new electronic products, analyze and predict system performance, conduct feasibility studies and participate in technical support of proposal and quotation effects. Perform technical liaison with new and existing customers and prepare technical papers.

SENIOR PROJECT ENGINEER

Prefer Masters Degree in Electrical Engineering or equivalent and 3-5 years of successful project management. Will plan and organize development of a product from concept to delivery. Provide technical guidance in product definition and development, determine project budget and schedule requirements. Provide technical direction to program personnel and maintain control of project documentation requirements.

DESIGN SPECIALIST

Prefer advanced degree in electrical or electronics engineering or equivalent and 5-7 years related experience. Will perform analog and digital instrument design. Must be knowledgeable in analog circuits and filters. Will analyze and predict system performance, conduct feasibility studies and participate in technical support of proposal and quotation efforts. Will provide predesign guidance and design concepts for new products.

SALES/APPLICATIONS ENGINEERS
(Detroit Area - San Francisco)

Well qualified instrument Sales/Applications Engineer to work with customers in developing new markets for spectrum analysis instruments, support field sales and provide inputs to design engineering. Prefer degree in Electronic Engineering or equivalent and extensive field sales experience. Familiarity with acoustic signal analysis and vibration monitoring/balancing instruments and systems required. Some structural dynamics experience preferred.

TECHNICAL SERVICES ENGINEER

Prefer advanced degree in Mechanical, Electrical Engineering or Physics. Responsibilities will include; writing and presentation of technical papers, assisting Product/Applications Groups in technical presentations to customers and in new product definition, introduction and application, including conducting seminars. Experience in technical phases of environmental testing, signal processing and mechanical systems. Minimum 3 years in a related assignment.

SENIOR SYSTEMS PROGRAMMERS

Prefer BS Degree in Computer Science or equivalent. Requires knowledge of BASIC APL & PLZ programming. Define block and logic flow diagrams, prepare test and debug complete programs. Requires 1-3 years related experience and basic electrical engineering and mathematical skills.

Excellent salary and benefits package.
Please send resume, including salary history to:

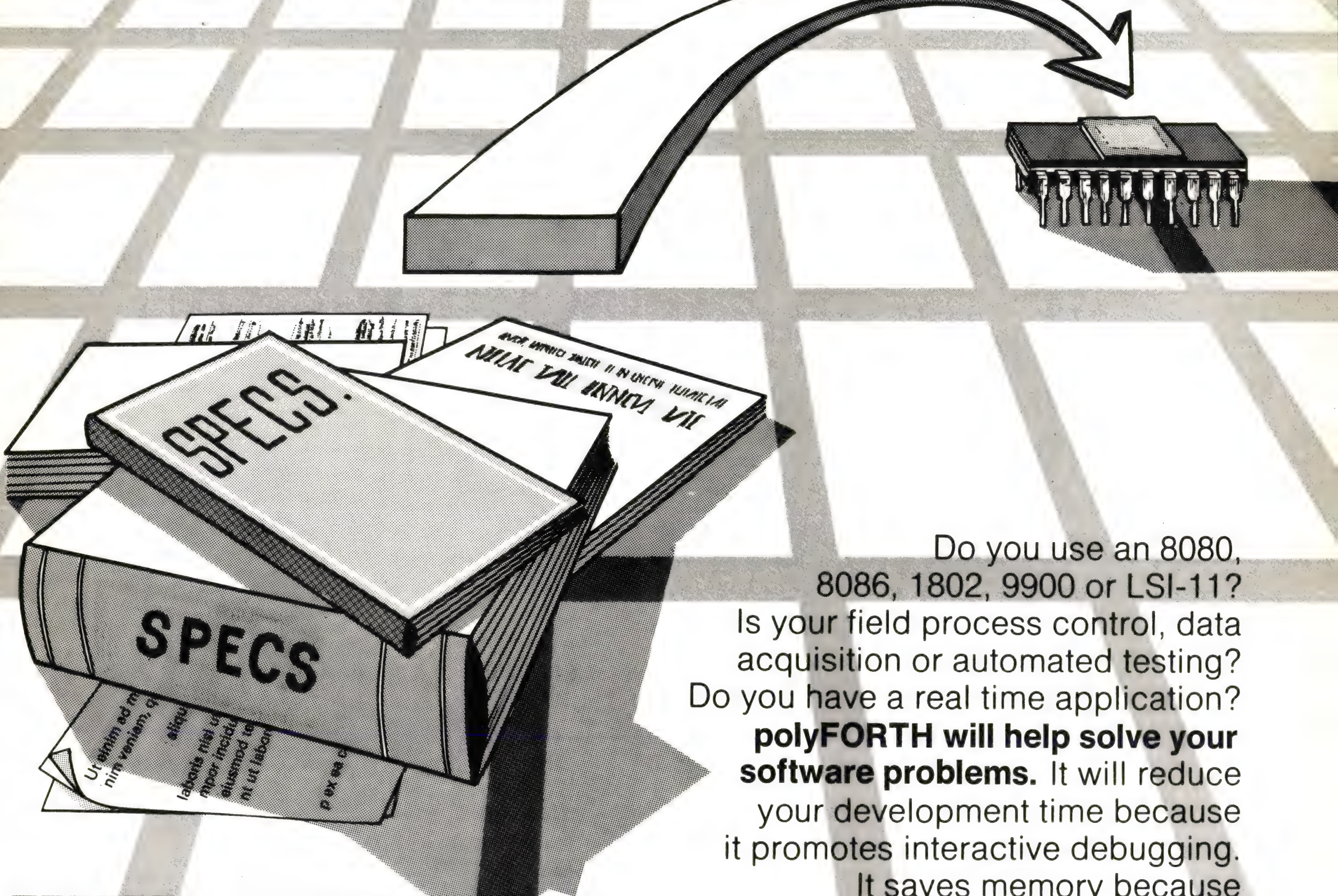
SPECTRAL DYNAMICS

A Scientific-Atlanta Subsidiary
Department 1123
4075 Ruffin Rd., P.O. Box 671, San Diego, CA. 92112
(714) 268-7001
An Equal Opportunity Employer

PUBLISHED EVERY TWO WEEKS

Because there is an issue of **Electronic Design** published every two weeks — 26 times a year — your help-wanted message gets into the marketplace quickly, yet gains the impact that only a technical journal can provide.

polyFORTH™ shrinks your big problem into a small PROM.



Do you use an 8080,
8086, 1802, 9900 or LSI-11?
Is your field process control, data
acquisition or automated testing?
Do you have a real time application?
polyFORTH will help solve your software problems. It will reduce your development time because it promotes interactive debugging. It saves memory because of its unique dictionary structure. It allows control of run time because it is a true multilevel language. It insures transportability because it is a virtual computer. And if your final program resides in PROM, polyFORTH's Target Compiler™ will produce exceptionally compact code. Let us tell you more. Send the coupon, attend a free seminar but first give us a call at: **213/372-8493**

OK, I'm interested!
Please rush full details on polyFORTH for
_______________ microprocessors
_______________ minicomputers
☐ Contact us for immediate requirements
Tel: (   ) ______________________
☐ Send dates and locations for your polyFORTH Seminars.

Name ______________________

Title ______________________

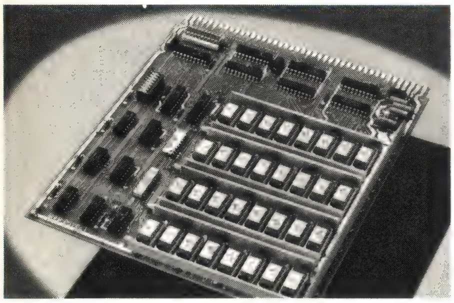
Attach coupon to company letterhead, and return to:
FORTH INC., 2309 Pacific Coast Highway,
Hermosa Beach, CA 90254. Or call (213) 372-8493.

FORTH, Inc.

CIRCLE NUMBER 134

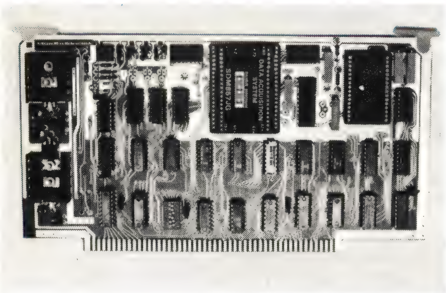
quick ads

New and current products
for the electronic designer
presented by their manufacturers.



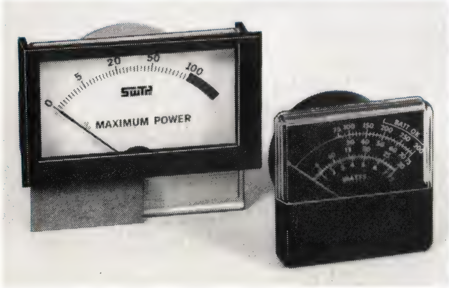
Mini/Bus® PC bus bars—When you want to take power and ground traces off the board to have more board area for signal interconnections, have higher density packaging, avoid multilayer boards, and reduce number of decoupling capacitors, use MINI/BUS® PC board bus bars. Rogers Corporation, Chandler, AZ. 85224. Phone: (602) 963-4584. EUROPE: Mektron N.V., Gent, Belgium JAPAN: Nippon Mektron, Tokyo.

PC Power Distribution **211**



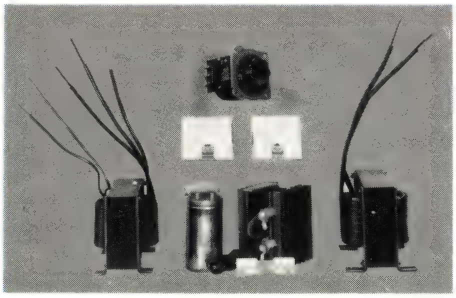
S-100 A/D CONVERTER, 12 BIT The Model AD-100 is a high quality, fast, 12 bit, 16 channel system. Available with programmable gain instrumentation amplifier and sample/hold. Operational Modes: Status Test, CPU Suspension, and 8080/Z80 interrupts. Basic board $575.00 plus options. Delivery - stock to 60 days. California Data Corp. 3475 Old Conejo Road, Suite C-10, Newbury Park, CA 91320 (805) 498-3651

CONVERTERS **212**



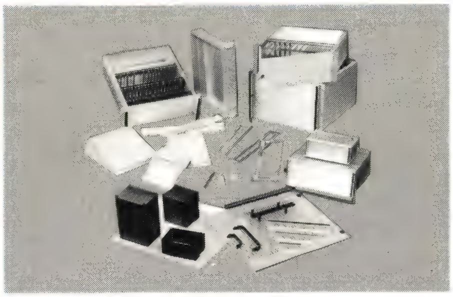
JEWELL SERIES 70 METERS include standard features such as taut band, pivot-and-jewell or AC iron vane mechanisms. For DC and AC operation in sizes of 1-1/2″ to 5-1/2″ including front panel illuminated dials with bezel mounting. Custom options include special dials with artwork and calibration, also special ranges, resistances and tolerances on internal resistances. Mirrored scales, painted covers or matching colors available. Write for free SERIES 70 METERS catalog; JEWELL INSTRUMENTS, INC. Grenier Field, Manchester, N.H. 03108, (603) 669-6400.

SERIES 70 METERS **213**



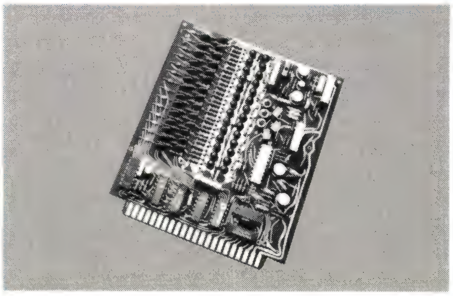
DC POWER SUPPLIES IN KIT FORM. Now available—major component groups as used in our standard production units. These can be incorporated into your consoles, plating benches and special configurations. Includes meters, silicon diodes mounted on adequate heat sinks, isolation transformers and stepless auto transformer voltage controls in a wide variety of DC outputs. Write for complete catalog of electroplating equipment. HBS EQUIPMENT DIVISION, DEPT. 543, 3000 Supply Ave., Los Angeles, CA 90040 (213) 726-3033

See us at NEPCON, Booth 872. **214**



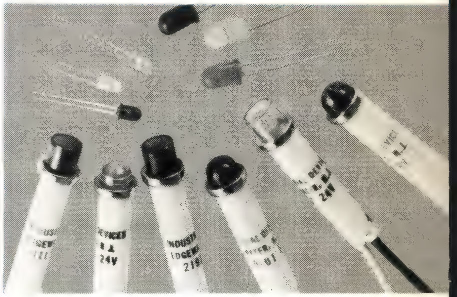
OFF-THE-SHELF ENCLOSURES. Techmar products combine precision workmanship and attractive, functional styling. Products include prefabricated rack-mounting chassis kits and parts, card cages, miniature consoles, portable instrument enclosures, subassembly housings, and power supplies. Available for immediate delivery. Dimensions, features, and ordering information are included in our free catalog. Techmar Corporation, 2232 So. Cotner Ave., Los Angeles, CA 90064, (213) 478-0046.

ENCLOSURES **215**



ADC 2000/2100 16-BIT A/D CONVERTERS for airborne, other critical applications. Resolution of ADC 2000/2100 series is 1 part in 65,535—16 binary bits or 2's complement; power consumption only 500 mw; accuracy: ±0.004%; linearity: ±0.002%; output control functions CMOS/TTL-LS compatible with any system. Tested, calibrated, system-ready except for power supply. ADC 2000: P.C. Card; ADC 2100: Encased. PHOENIX DATA, INC., 3384 W. Osborn, Phoenix, AZ 85017. PH 602/278-8528.

A/D CONVERTERS **216**

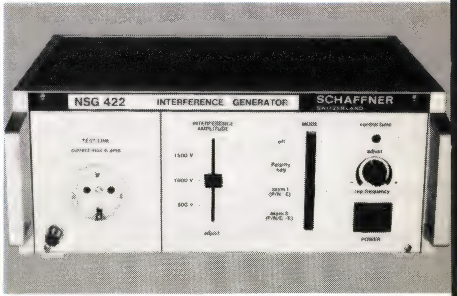


GET FREE SAMPLES of new Super-Brite LED indicator lights from Industrial Devices, Inc., Edgewater, N.J. 07020. Red, green, yellow, 100,000-hr. life. Low ac or dc power-drain, high reliability, shock-resistant. Fit 5/16″ holes. Hemispheric or flat-top. Ideal for solid-state and battery. Off-the-shelf for 6, 12, 24 volts. Call Toll Free 800-526-0488. In N.J. cal 201-224-4700

SAMPLE LED LIGHTS **217**

AC/DC CLAMP-ON AMMETER MEASURES TRUE RMS AC World's first handheld AC/DC digital clamp-on ammeter checks 1-800 amps AC & DC current, including SCR Circuits, with accuracy of 1½% of reading. Simply clamp around the current carrying conductor & read the current with the remote digital display. I checks conductors to 1¼ inches with its lightweight 8 oz. tong. Laboratory accurate rugged, simple to use. Heavy duty leatherette case included. Model 1800A only $345. PACER INDUSTRIES, INC., 704 East Grand Ave., Chippewa Falls, WI 54729. (715) 723-7110

CLAMP-ON AMMETER **218**

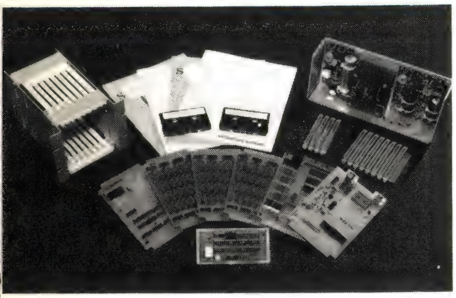


Line interference simulator The newest low priced line power interference simulator NSG 422 tests the reaction of electronic equipmen to interference pulses with fast rise time as they are generated by switches, relays etc Pulse rise time 5 ns, pulse width 100ns, pulse amplitude up to 1600 volts. H. Schaffner AG CH-4708 Luterbach, Switzerland, TY 34491

LINE INTERFERENCE SIMULATOR **219**

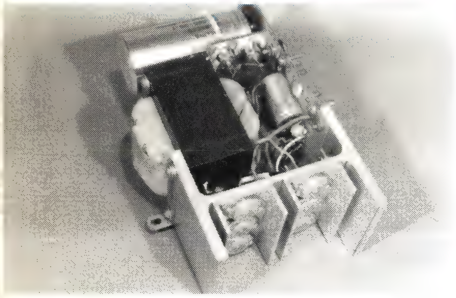
quick ads

New and current products
for the electronic designer
presented by their manufacturers.



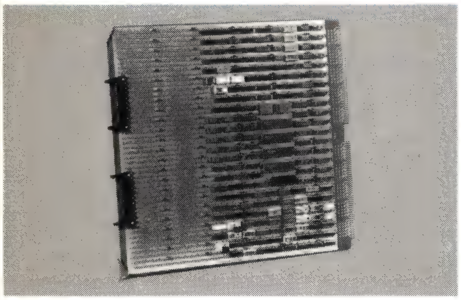
6800 DEVELOPMENT PAC II. Consisting of 6800 CPU, 48K Ram, Erom Programmer, RS-232 interface with switch selectable rates to 9600 baud, cassett interface for 300/2400 baud, *FANTOM-II monitor/debug ROM, editor/assembler, 4K BASIC, card rack, 7 socket back plane, large power supply. All for $1,895. Wintek Corp., 1801 South Street, Lafayette, IN. 47904; 317-742-8428

6800 DEVELOPMENT PAC II **220**



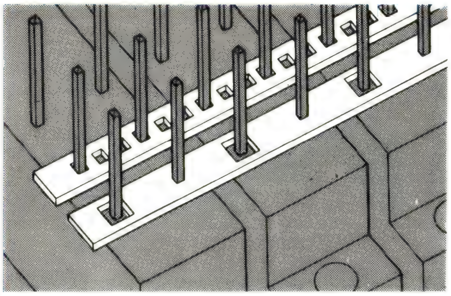
SBC SERIES power supply by LITE-CON The SBC series of OEM power supplies represents a new concept incorporating standard JEDEC components. By optimizing the heat sink extrusion and packaging technology LITE-CON is able to reduce the overall volume of these linear supplies by 40% while isolating heat generating and heat sensitive components. All components are accessible and replaceable without disassembly. AVAILABLE FROM: LITE-CON, INC., Brownsville Compress Bldg. T-113, P.O. BOX 3342, BROWNSVILLE, TX. 78520

OEM POWER SUPPLIES **221**



MIL-STD-1553A INTERFACE FOR NOVA/ECLIPSE COMPUTERS. Bus Control Unit model number BCU-16 provides a flexible interface for 3, Data General's NOVA/Eclipse and equivalent computers. The unit operates as a bus controller, remote terminal (RT), or bus monitor. Another feature of this BCU is the capability to simulate multiply RT's. SCI SYSTEMS, INC., 8600 South Memorial Parkway, Huntsville, AL 35802 (205) 883-4800, Extension 251.

BUS CONTROL UNIT **222**

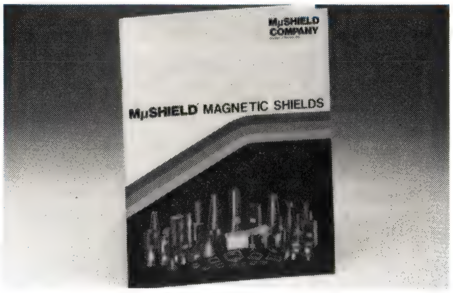


STRIP/BUS BY ROGERS. Low Cost Bussing Systems; easy installation, reliable solder joints; greater pin exposure. Write or call for details. Rogers Corporation, Chandler, AZ 85224. Phone (602) 963-4584. (EUROPE: Mektron NV, Ghent, Belgium; JAPAN: Nippon Mektron, Tokyo)

STRIP/BUS **223**

THE COOLERS. EAD blowers help keep your product running cool. Quietly, reliably. Ball bearing construction is one indication of the exceptional quality. There are single and dual centrifugal blowers. Filtered box blowers. And there's another way to cool it. With EAD fans. Vaneaxial. Propeller. Tubeaxial. If you're moving air, from 3 to 2000 cfm, contact Eastern Air Devices, Dover, NH 03820, (603) 742-3330.

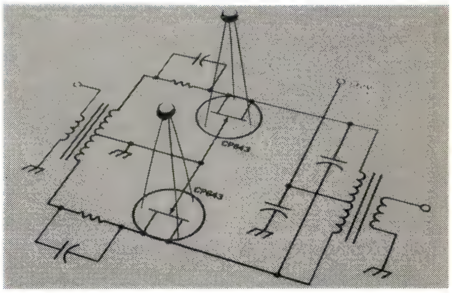
BLOWERS AND FANS **224**



FREE DESIGNER'S GUIDE AND MUSHIELD CATALOG presents standard and custom magnetic shields for storage, photomultiplier, and cathode ray tubes, ESCA, auger spectrometers, and special applications. Magnetic shielding materials available in sheets and coils, and preserver cases for magnetic tape, are listed. A "must have" reference for the design engineer. MuShield Corp., 151 Madison St., Malden, MA 02148. (617) 321-4410.

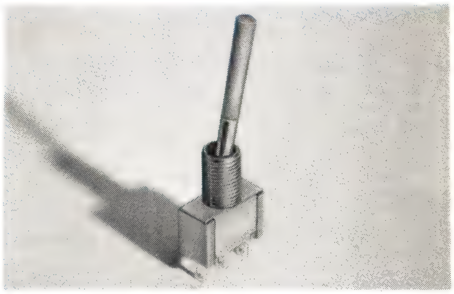
MAGNETIC SHIELDS **225**

PRESSURE SENSITIVE STICKERS SHOW EXCESS TEMPERATURES. Make trouble-shooting easy. A triangular symbol on the sticker permanently changes from white to black when the specified temperature of equipment is exceeded for only seconds. CelsiStrip® 5- or 8- temp sequenced triangles. Range 40-260°C/ 105-500°F 1% SAT Inc., 357 Cottage St., Springfield, MA 01104 (413) 788-6191 TWX-710-350-6466 SPIRIG P.O. Box 160 CH 8640 Rapperswil, Switzerland (055) 274403 telex 875400.
CELISDOT
FREE SAMPLES **226**



HF/VHF JFET RF AMPLIFIER Use the low noise, wide dynamic range CP643 in applications through 500 MH_z. The versatile device has a g_m of 25,000 µmhos @ 25 mA IDS, and makes an ideal IF preamp, presenting a constant 50 Ohm input impedance over 1 to 108 MH_z range, a near-perfect termination for diode double-balanced mixers. Other applications are: receiving multicouplers, high purity oscillators, active mixers. RF and IF amplifiers. Price: $4.41 at 1,000. Teledyne Crystalonics. 147 Sherman St., Cambridge, MA 02140 (617) 491-1670.

AMPLIFIER **227**

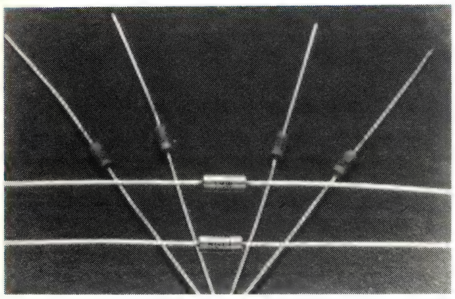


Presenting nine beautiful ways to positively identify function, glorify instrument panel appearance and help guard against static electrical shock. It's C & K's long-stemmed L3 nylon toggle in red, white, and blue, yellow, green, brown, orange, black, and grey. These plastic covered miniature switches have a contact rating up to 5 amps including dry circuit applications. C & K COMPONENTS, INC., 15 Riverdale Avenue, Newton, MA 02158. (617) 964-6400, TELEX: 92-2546, TWX: 710 335 1163.

TOGGLE SWITCHES **228**

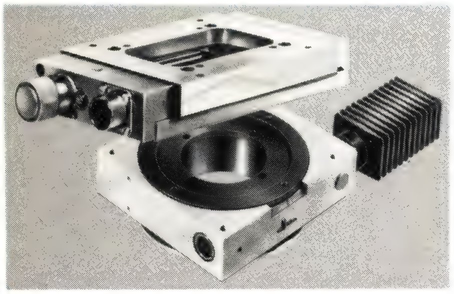
quick ads

New and current products
for the electronic designer
presented by their manufacturers.



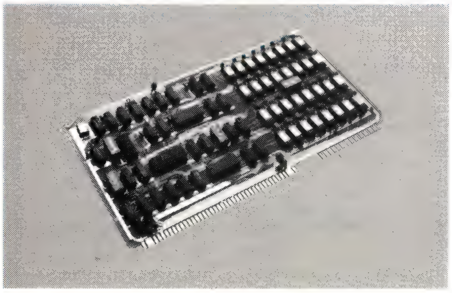
LOW COST TEMPERATURE SENSORS FROM TRW. Provide alternative to thermistors, RTDs and thermocouples in the −55° to +175°C (−67° to +347°F) temperature range. Ideal for controls, instruments, appliances and automotive circuits. A stable Metal Glaze (TM) on-ceramic element offers near-linear change in resistance of minus 0.3%/°C, fast response time, and very small physical size (maximum length 1/4 inch). TRW/IRC Resistors, an Electronic Components Group of TRW Inc., Greenway Road, Boone, N.C. 28607. (704) 264-8861.

TEMPERATURE SENSORS **231**



MICROPOSITIONER POWER STAGES Translation Stages have single axis movement to 125mm; stackable for XY or XYZ Motion; zero backlash; & positioning to within 1 μ. Motor or manual operation. Rotation Stages are backlash free thru 360°; resetable to 0.001 arc degree. Motor or manual operation. Request. Catalog 409. Klinger Scientific, 110-20 Jamaica Ave., Richmond Hill, N.Y. 11418, (212) 657-0335

MICROPOSITIONERS **232**

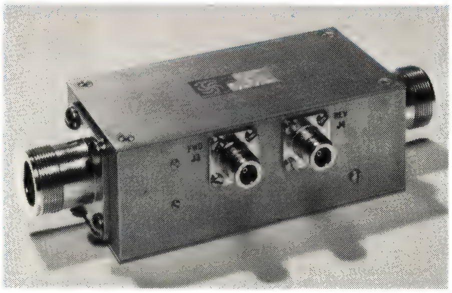


RELM's RMEM-64/8+16 (byte swap) and RMEM 64/8+16. Memory Boards feature 250 nanosecond access time, page switching option, on-board refresh and sequential refresh.

- RMEM-64/8+16: use with 8+16 bit bus masters; allows 1 megabyte or ½ megaword addressability-$1,700.00
- RMEM-64/8⊕16: access in 8-bit or 16-bit mode; 1 megabyte memory in byte mode and 1 megaword in word mode-$1,600.00

Order from RELMS, Relational Memory Systems, Inc., 1180 Miraloma Way, Sunnyvale, CA 94086, (408) 732-5520 TWX 910 379 0014

MEMORY BOARDS **233**

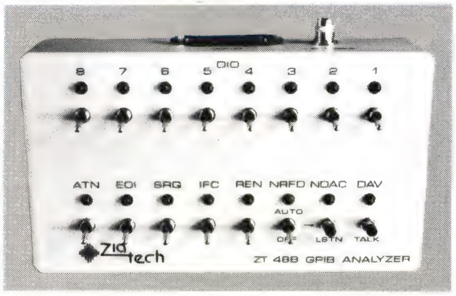


Multi-Octave Directional Couplers are available in uni and dual output versions covering the range of 10KHz to 1 GHz. Bandwidths up to 14 octaves are covered at power levels to 10Kw. Typical is our 10Kw Model C1449 which exhibits a 70±1db coupling factor over the 1-100 MHz frequency range, directivity exceeding 20db, and 1.05:1 maximum VSWR. Catalog sent on request. WERLATONE INC. P.O. Box 47 Brewster, N.Y. 10509 (914) 279-6187.

DIRECTIONAL COUPLERS **234**

E-T-A COMBINATION SWITCH/CIRCUIT BREAKERS Combination saves you money because it eliminates using individual switch, circuit breaker or fuse and light. You buy, stock, mount and wire only one component. Very high reliability with 50,000 cycles mechanical and 25,000 cycles at rated load. Six handle colors. Lighted version available. Current ratings from 3 amp thru 16 amp at 250 Vac (125 Vac). UL 1077 and other world-wide approvals. Single pole about $2.50 in production quantities. E-T-A Circuit Breakers, 7400 N. Croname Rd., Chicago, IL 60648 Tel. (312) 647-8303.

235



Ziatech's ZT 488 is the first truly low cost, handheld logic analyzer for the IEEE 488 Interface Bus (GPIB). Priced lower than the cost of the technician time required to build your own, you get not only an analyzer, but a bus controller, too. The ZT 488 will pay for itself in the time saved finding just one bug in a GPIB hardware or software system. It also saves user time and $ early in a project when used to simulate GPIB devices, proposed instrument designs and data protocols. Price - $399. 805-541-0488. Ziatech Corporation, 2410 Broad Street, San Luis Obispo, CA 93401

GPIB ANALYZER **236**

Electronic Design

ELECTRONIC DESIGN'S function is:

- To aid progress in the electronics manufacturing industry by promoting good design.
- To give the electronic design engineer concepts and ideas that make his job easier and more productive.
- To provide a central source of timely electronics information.
- To promote communication among members of the electronics engineering community.

Want a subscription? ELECTRONIC DESIGN is circulated free of charge to those individuals in the United States and Western Europe who function in design and development engineering in companies that incorporate electronics in their end product and government or military agencies involved in electronics activities. For a free subscription, use the application form bound in the back of the magazine or write for an application form.

If you do not qualify, paid rates for a year's subscription (26 issues) are as follows: $35. U.S., Canada, Mexico, Central America. International annual subscription rates listed below include air delivery: $65. Europe; $100. Mideast, North Africa, South America, Japan; $130. Central and South Africa, New Zealand, Australia and all other Asia. Single copies (when available) may be purchased for $4. U.S., Canada, Mexico, Central America and $5. in all other countries. The GOLD BOOK (27th issue) may be purchased for $35. U.S., Canada, Mexico, and $45. all other countries.

If you change your address, send us an old mailing label and your new address; there is a card bound into the back of the magazine for this purpose. Please allow 6 to 8 weeks for address change to become effective. You must requalify in order to continue receiving ELECTRONIC DESIGN free of charge.

The accuracy policy of ELECTRONIC DESIGN is:

- To make diligent efforts to ensure the accuracy of editorial matter.
- To publish prompt corrections whenever inaccuracies are brought to our attention. Corrections appear in "Reader Feedback."
- To encourage our readers as responsible members of our business community to report to us misleading or fraudulent advertising.
- To refuse any advertisement deemed to be misleading or fraudulent.

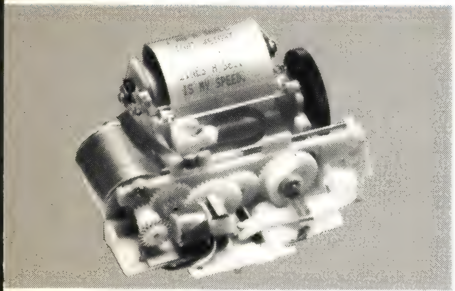
Individual article reprints and microfilm copies of complete annual volumes are available. Reprints cost $6.00 each, prepaid ($.50 for each additional copy of the same article), no matter how long the article. Microfilmed volumes cost $23 for 1976 (Vol. 24); $30 for 1973-75 (Vols. 21-23), varied prices for 1952-72 (Vols. 1-20). Prices may change. For further details and to place orders, contact Customer Services Dept. University Microfilms, 300 N. Zeeb Rd., Ann Arbor, MI 48106. (313) 761-4700.

Want to contact us? If you have any comments or wish to submit a manuscript or article outline, address your correspondence to:

Editor
ELECTRONIC DESIGN
50 Essex St.
Rochelle Park, NJ 07662

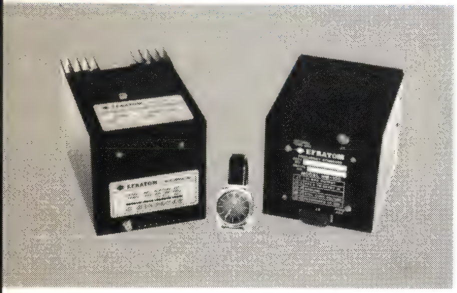
quick ads

New and current products
for the electronic designer
presented by their manufacturers.



SMALL, PORTABLE DISCHARGE PRINTER DC-1206B prints 12 characters/line nominal, but is capable of 15 columns. Sized for portable, hand-held equipment it is 1.7″ H x 3.2″ W x 3.7″ D, weighs only 5.3 ounces. It prints 5 lines/sec. on 1/4″ paper. It's priced at only $52 in 100 quantity. Other printers with interface electronics available. HYCOM, 16841 Armstrong Ave., Irvine, CA 92714 (714) 557-5252.

PORTABLE DISCHARGE PRINTER 237

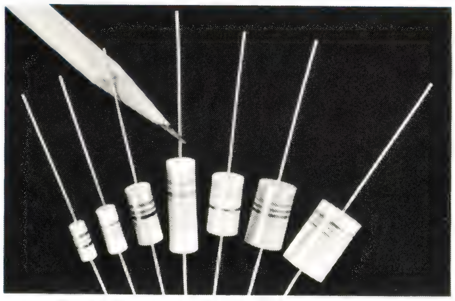


RUBIDIUM OSCILLATORS MODEL FRK. Stability: 1×10^{11}/month; 1×10^{12} τ = 100s. **Frequency:** 10 MHz, Option 5 MHz, 1 MHz High spectral purity and low phase noise. **Reliability:** >30000 hours MTBF for Mil. **Fast warmup:** <10 min. 2×10^{10} and low power. **Light and small:** 4 × 4 × 4.5″, 2.9 lbs. **Applications:** Radio navigation; Position location; guidance; and secure communications. **EFRATOM** 18851 Bardeen Ave., Irvine, Calif. 92715. Phone (715) 752-2891.

OSCILLATOR 238

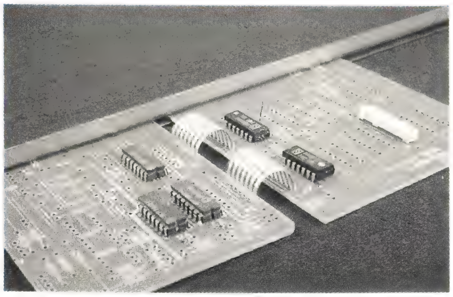
For Product Samples
For Special Offers
use
QUICK ADS
and reach your
prime audience
Phone
(201) 843-0550

239



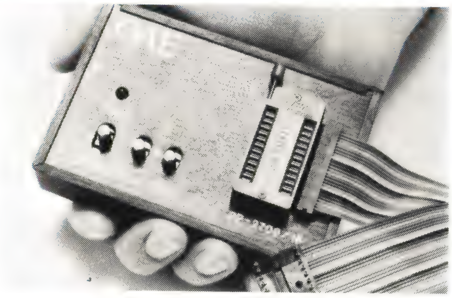
Molded Mini RF Chokes—Shielded/Unshielded Where extraneous coupling presents problems shielded RF chokes limit coupling to less than 3% when units are placed side by side; Mfg. in accordance with MIL-C-15305; 100-page catalog on request. J.W. MILLER DIVISION, Bell Industries, 19070 Reyes Ave., Compton, CA 90221 (213) 537-5200.

SHIELDED/UNSHIELDED
MINI RF CHOKES 240



FLEXIBLE HORIZONTAL JUMPERS—Space saving one-piece circuits simplify PCB design, reducing need for expensive multi-layer circuits. Also useful as hinge to join two boards. Rigid integral pins plug directly into board holes or connector sockets. Many standard widths, lengths and conductor centers to meet design needs at minimum cost. Custom configurations also available, including integral pads for solder termination. BMC Box 888, Nashua, NH 03061 (603) 883-5541

ONE-PIECE CIRCUITS 241



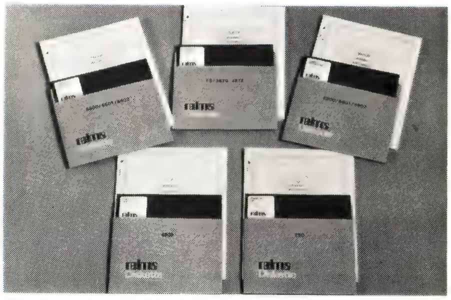
OAE's PP-Series EPROM Programmers plug directly into any vacant EPROM socket and allow you to transfer data directly from RAM to EPROMs. No additional power supplies are required. All timing & control sequences are handled by the programmer. Each unit includes internal DC to DC switching regulator, ZIF & 4 ft. ribbon cable terminated with a 24 pin plug. Programmers are available for all EPROMs from 2708's thru 2732's. Oliver Advanced Engineering, Inc., 676 W. Wilson Ave., Glendale, CA 91203 (213)240-0080 or Telex 194773.

PP SERIES PROGRAMMERS 242

POWER/MATE MAKES SWITCHER HISTORY.
5 Volts 10 Amps
$89.
THE SWITCHER COST BREAKTHROUGH YOU'VE BEEN WAITING FOR!
POWER/MATE CORP.
POWER/MATE MAKES MULTIPLE OUTPUT SWITCHER HISTORY.
Five Regulated Outputs 100 Watts
$199.
THE SWITCHER COST BREAKTHROUGH YOU'VE BEEN WAITING FOR!
POWER/MATE CORP.

NEW SWITCHING POWER SUPPLY CATALOGS introduce the single and multiple output switching power supplies that break the switcher price barrier wide open! Top quality open-frame switching supplies with exceptional efficiency and compactness ...yet they are competitive in price with many open frame linear supplies. MTBF well over 50,000 hrs. Two-year Warranty. Meet UL and CSA standards. Power/Mate Corp., 514 South River St., Hackensack, NJ 07601 (201) 440-3100.

POWER SUPPLY CATALOGS 243



RELM's Relocatable Macro-Assemblers (RMA's) expand your Intellec® system. Completely compatible with Fairchild, Motorola, Mostek and Zilog definition features, produce ISIS II compatible output. F8/3870/3872; 6500/6501/6502; 6800/6801/6802; 6809; and Z80—each $500.00. Includes operator's manual, software license, one-year warranty and update. Order from RELMS, Relational Memory Systems, Inc. 1180 Miraloma Way, Sunnyvale, CA 94086, (408)732-5520, TWX 910 379 0014. Intellec® is a registered trademark of Intel Corporation.

RELOCATABLE MACRO-ASSEMBLERS 244

SOLID STATE DIRECTIONAL REFERENCE SYSTEM MODEL NO. FD13-0101-1. For continuous reference to magnetic north. Uses standard sine-cosine flux detector windings suspended on universal joint with tilt angles up to 30°, two outputs of 2.5 VDC each for sine and cosine of heading angles when in earth's magnetic field of 0.25 gauss. Accuracy within 1.5° of earth's local magnetic north. 28VDC, 40ma 3.25″ diameter, weighs 1 lb. Humphrey, Inc. 9212 Balboa Ave., San Diego, CA 92123 Telephone (714) 565-6631.

SOLID STATE REFERENCE SYSTEM 245

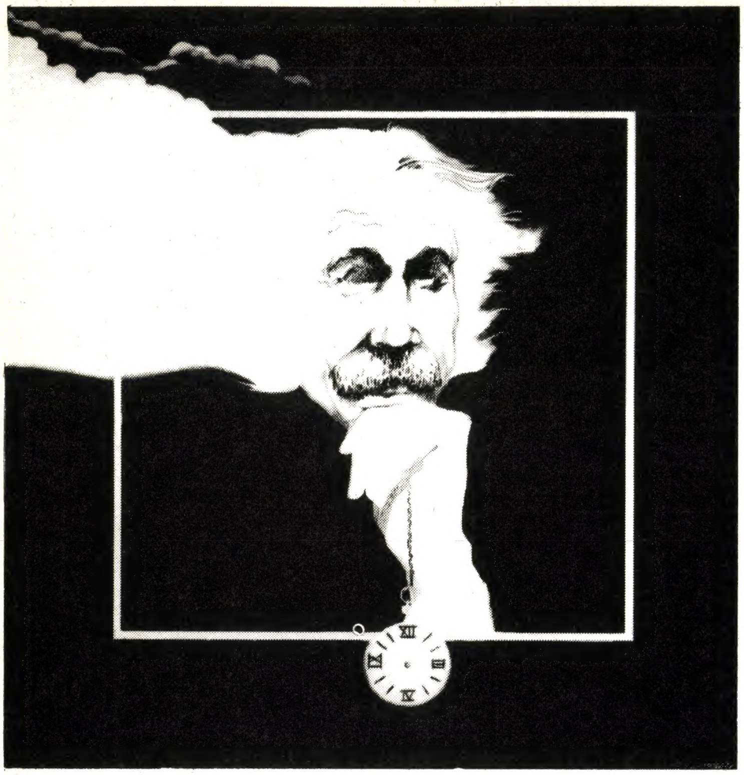
Advertiser's Index

Advertiser	Page
AMP, Incorporated	106-107
Abbott Transistor Laboratories, Inc.	10
Acopian Corp.	202A
Adcomp	32H
Advanced Micro Devices	8-9
Airpax Electronics, Cambridge Div.	177
Airpax Electronics, Cheshire Div.	179
Analog Devices Inc.	100
Applied Microsystems	32J
Aromat Corp.	162
Avantek, Inc.	159
BMC	225
Beckman/Helipot Division	186H
Berg Electronics, Inc.	170-171
Bourns, Inc., Controls Div.	Cover IV
Brand Rex Company	61
Buckeye Stamping Company, Inc., The	175
Burndy Corporation	16D-E
Burr-Brown Research Corporation	22
Burroughs Corporation	53
C & K Components, Inc.	253
CTS Corporation	153
Caddock Electronics	14
California Data Corp.	252
Cambion	192, 213
Catalyst Research Corp.	56
Centralab Distributor Products, Globe-Union, Inc.	164-165
Christie Electric Corp.	222
Computer Automation, Inc.	15
Conner-Winfield Corp.	222
Cromemco	16
Dale Electronics, Inc.	4
Data I/O Corporation	195
Data Precision Corporation	199
Datel Intersil	166-167, 174, 185
Dialight, A North American Philips Company	114
DOSC Inc.	148
Dynetic Systems Corp.	218
Dynascan Corporation	18
EAO Switch Corp.	202G
E-T-A Products Co. of America	253
Eastern Air Devices	253
Eaton Corp., Commercial Controls Div.	149
Efratom California, Inc.	255
Electro Switch Corp.	218
Electronic Development Corp.	123
Electronic Devices, Inc.	225
Electronic Hardware	212
Electronic Measurements, Inc.	173
Electronic Molding Corporation	217
Electronic Navigation Industries	189
Fairchild Semiconductor, A Division of Fairchild Camera and Instrument Corporation	258
Fluke Mfg. Co., Inc., John	21
Forth, Inc.	251
G & H Technology	186
General Electric Company	136
General Instrument Corporation, Microelectronics Division	54-55
General Magnetics	184
Gold Book, The	217, 226
Gould, Inc., Electronic Components Santa Clara	105
Gould, Inc., Instruments Division	42
Gould, Inc., International	32E
Gralex Industries, Division of General Microwave Corp.	203
Grayhill, Inc.	168-169
Gulton Industries, Inc.	198
H.B.S. Equipment	252
H.B.S. Equipment	252
Harris Semiconductor, A Division of Harris Corporation	84-85
Harting	32L
Hartwell, Corp.	226
Hayden Book Co.	*183
Heinemann Electric Company	223
Hewlett-Packard	*69, 70, 71, *72, 73, 74
Hitachi Electronics Co., Ltd.	186B-C
Humphrey, Inc.	255
Hycom, Inc.	255
ILC Data Devices, Inc.	6, 46
IMC Magnetics Corporation	215
Industrial Devices Inc.	252
Instrument Specialties Company	180-181
Intel Magnetics	12-13
Intel Memory Systems	142-143
Intersil	80-81, 96-97
Interdesign, Inc.	201
Ion Physics Corporation	219
Italtel	32M
Janco Corporation	11
Jepico, Co., Ltd.	32K
Jewell Electrical Instrument, Inc.	252
Kel-Am Co.	208
Keystone Electronics Corporation	95
Klinger Scientific Corp.	254
Koutron Electronics, Inc.	186A
Lanier Business Prods., Inc.	202D-E
Litcon	253
Litronix, Inc.	32, 186F
Lorain Products Corp.	144
3M Company	90
Metex Corporation	205
Methode Electronics, Inc.	108
Miller Bell, Ind.	255
Miller-Stephenson Chemical Co., The	160-161
Mini-Circuits Laboratory, A Division of Scientific Components Corp.	2, Cover III
Monolithic Memories, Inc.	16B-C
Motorola Semiconductor Products, Inc.	33-40
Mushield	253
Murata	16G
NEC Micro Computers, Inc.	186D-E
National Semiconductor Corporation	90A-F
Nichion Corporation	16A
Nicolet Instrument Corp.	183
Non-Linear Systems, Inc.	132, 196, 202, 219
OK Machine & Tool Corporation	178
PPG Industries, Inc.	193
Pacer Industries, Inc.	252
Panasonic Electronic Components	Cover II
Penndixon, Div., of Dixon Ind.	223
Philips Test & Measuring Instruments, Inc.	32B, 186G
Phoenix Data, Inc.	252
Plessey Capacitors	*32
Pomona Electronics, A Division of ITT	191
Power Interface	190
Power/Mate Corp.	255
Power One, Inc.	206
Power Products Div., of Computer Products	194
Precision Monolithics, Incorporated	66-67
Pyrofilm Corporation	188
Qantex	17
Quantronix Corp.	209
RCA	157, 182
Racal-Milgo	235
Racal-Recorder	82-83
Relational Memories Systems	29, 254, 255
Reticon, EG&G	197
Rhombus Industries, Inc.	30
Rockwell International	124-125, 230
Rogers Corporation	252, 253
Rohde & Schwarz	252
Rolm Corporation	27
Rowe Industries	221
SCI Systems, Inc.	253
SGS Ates Semiconductor Corporation	150-151
SMK Electronics Corporation of America	210
Sanyo Communications Products Div.	16F
Servometer	221
Shugart Associates	98-99
Siemens Corporation	16H, 202D,E
Spectrol Electronics Corporation	133
Spirig	254
Sprague Electric Company	76, 172
Standex Electronics Co.	225
Star Micronics	217
T & B/Ansley Corporation	75
T-Bar, Incorporated	31
TRW/IRC	254
TEC Inc.	204
Techmar Corp.	252
Tektronix IDP	115
Tektronix, Inc.	62, 79, 134-135
Teledyne Crystalonics	253
Texas Instruments, Incorporated	116-117, 228
Triplett Corporation	155
Unimax Switch Corporation	227
Union Carbide, Electronics Div., Components Department	141
VRN International	211
Vectrol, Inc.	200
Verbatim Corp.	207
Victoreen Instrument Division Shellar-Globe Corporation	187
Wakefield Engineering, Inc.	182
Waters Manufacturing, Inc.	196
Wavetek San Diego, Inc.	1
Wells Electronics Inc.	202F
Werlantoe Inc.	254
Wescon	215
Weston	202H
Wickmann-Werke Ag	32H
Wiltron Company	175
Wintek Corporation	253
Woven Electronics	126
Ziatech	254

Recruitment

Frank Leonard Personnel	134
TRW Semiconductors	134
Racal Milgo	235
Inmas	236
Bell Laboratories	237
Gould	238
Harris Semiconductors	239
Martin Marietta	240
Signetics	241
Digital	242
Automation Industrues	242
Wallach Assocl Inc.	242
Magnavox	243
Northrop	244
Genrad	244
MCR	246
Racal-Milgo, Inc.	247
Milton Bradley Co.	248
General Electric	249
Honeywell	250
Spectral Dynamics	250
Aerospace	256

**Advertisers in International Edition*



Albert Einstein on space:

"Look to the heavens and learn from them."

THE men and women of The Aerospace Corporation feel a special commitment to the great physicists words.

In the past 19 years, we have devoted more than 30,000 engineering/scientific staff years to over 50 spacecraft, boosters, and missile systems. At Aerospace, we are already planning how man will use space through the end of this century and the first half of the next one.

The primary mission of The Aerospace Corporation is to provide general systems engineering and integration for the U.S. Government, primarily Air Force space programs.

Activities at The Aerospace Corporation are concentrated in the following thre technical areas:

The Engineering Group

The Engineering Group performs professional engineering work in these general classifications: Electronics and Optics; Guidance and Control; Orbital and Environmental Analysis; and Vehicle Engineering. It also provides Data Processing and Analysis support to the Corporation through the Information Processing Division.

The Programs Group

The Programs Group engages in general systems engineering and integration on current programs primarily for defense agencies and for non-defense agencies in national security-related activities.

Systems Engineers work as members of the Air Force/Industry team. We participate in a variety of systems and subsystems—for satellites, launch vehicles, and ground support areas—in the full range of engineering disciplines. We are also involved in many other projects related to national security.

The Development Group

The Development Group joins together advanced programs, new space systems, engineering and programs-related laboratory research for strong interaction between new technology and new system ideas. The Development Group, in brief, is futures-oriented.

Opportunities in the above groups exist in the following areas:

Communication/Satellite

Traveling Wave Tube Amplifier Engineers
RF Engineers
Spaceborne Digital Electronics
Satellite Integration and Test
Electrical Circuit Engineers
TT&C and Power

Optics

Infrared Focal Plane Engineers
Infrared Optical Systems Engineers
Optical Design and Analysis Specialists
Infrared Detector Specialists
Electro-Optical Systems Analysts

Communication/Telemetry

Communications Systems Engineers
Communications Systems Analysts
Positions available in both Los Angeles and Bay area
Command and Telemetry Engineers
Satellite Borne Communications
RF Systems
Data Communications Systems
Positions available in both Los Angeles and Bay Area
Communication Technology
TT&C Systems

Reliability

Component Engineers
Failure Analysis Engineers
Product Assurance Engineers
Product Design Engineers
Reliability/Maintainability Systems Engineers

Electronics/Electrical

Advanced Systems Project Engineers
Microwave Research Scientist/Engineer
Radar Systems Engineers
Electronic Circuits Analysts
Power Systems Engineers
Digital Circuits
Electronic Payload
Electric Utility Systems Planning
Electrical Systems Test
ECM Systems
Spacecraft Systems

You'll like it here at The Aerospace Corporation. We offer an excellent salary and benefits program including fully paid medical and dental insurance, full tuition reimbursement, seven year vesting retirement program, tax-deferred savings plan, 3 weeks vacation your first year and 4 weeks after 3 years.

Successful candidates should have a minimum of a BS in Engineering/Science and at least four years of recent directly related experience.

Qualified individuals are invited to forward resume with salary history and salary requirements to:

Professional Placement
Box ED 280
2350 E. El Segundo Blvd.
El Segundo, CA 90245

The Aerospace Corporation
The Systems Architect/Engineer

U.S. Citizenship Required
An Equal Opportunity Employer

SENTRY® VII. IF IT WEREN'T SO FAR AHEAD, LSI WOULD BE A LOT FARTHER BEHIND.

Fairchild's Sentry VII is the most advanced general-purpose LSI test system available anywhere. There are more of them used in device development labs today than any other test system. And most important, virtually every LSI device designed over the past four years has been developed on one.

THE STUFF STANDARDS ARE MADE OF.

Sentry VII has truly become the industry standard. And for some pretty good reasons.

It's at home anywhere. Whether handling complex engineering characterization, keeping a close check on production standards at the manufacturer, or scrutinizing incoming components at the end user.

Its flexibility in testing a broad range of device types and technologies is unmatched. Sentry VII routinely handles microprocessors, peripheral chips, bit slices, RAMs, ROMs, shift registers, UARTs and digital hybrids in technologies such as NMOS, PMOS, CMOS, HMOS, XMOS, SOS, ECL, DTL, TTL and I^2L.

In addition, Sentry's exclusive modular architecture allows you to choose from a variety of high-performance options to suit your needs. One module gives you real-time data logging and analysis. Another enhances the timing capability of the system. There's a module that expands the system's analog capability. And another that lets you perform subnanosecond time measurements with a resolution of ten picoseconds. Add to all this the IEEE bus for external instrumentation and you've got the most versatile LSI test system you can find anywhere.

LOTS OF EXTRA BENEFITS.

When you buy a Sentry VII, you get a lot more than just hardware. Like program compatibility within the Sentry family. Most Sentry software developed over the past 10 years will run on a Sentry VII. That helps protect your software investment and allows you to draw from a vast number of programs for just about any LSI device ever made.

You also get a product with proven reliability and the best uptime record in the industry. Not to mention service, training and applications support unsurpassed by any other test system manufacturer.

But don't take our word for it. Just ask anyone who uses a Sentry VII. If it weren't so far ahead, they might not be, either.

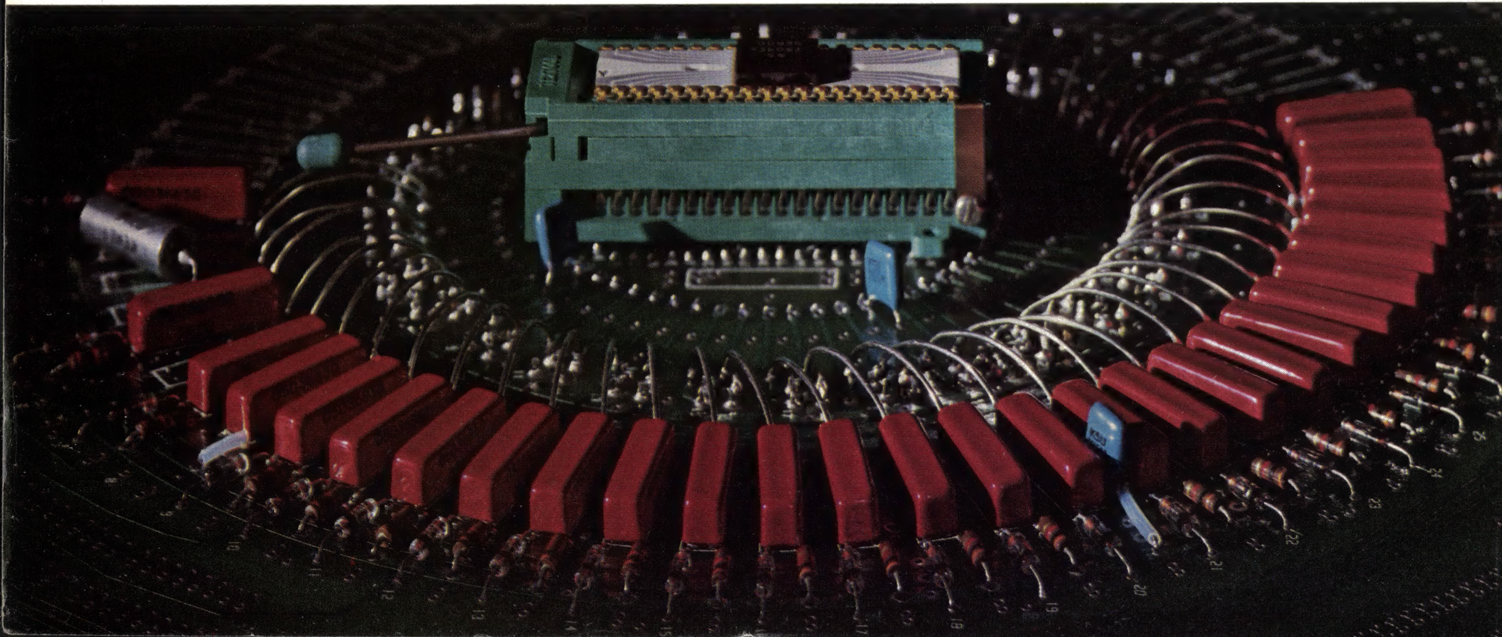
For more information, give us a call at (408) 998-0123. Or write Fairchild Test Systems Group, Fairchild Camera and Instrument Corporation, 1725 Technology Drive, San Jose, California 95110. TWX: 910-338-0558.

FAIRCHILD

TEST SYSTEMS GROUP

CIRCLE NUMBER 135

The first family of ATE.



Now Available...

MIXERS with a 3 year guarantee!

$7.95 from **SRA-1**(500)

Three years ago, Mini-Circuits offered a two-year guarantee for its industry-standard **SRA-1** hermetically-sealed double-balanced mixer . . . now used world-wide for a variety of military and industrial applications. The two-year guarantee was made possible by the use of an accelerated-life screening test for diodes generally reserved only for space applications. The HTRB-screened Schottky diodes are subjected to a one-volt negative bias at 150° C for 168 hours, a stress designed to accelerate ageing and force time-related failures—thus screening out potentially unreliable devices.

Now Mini-Circuits is proud to offer a **three-year guarantee** for the **SRA-1** achieved by further stressing and testing the assembled unit. Each completed **SRA-1** experiences: 1. Burn-in for 96 hours at 100° C with 8 mA at 1 kHz. 2. Thermal shock. 3. Gross and fine leak tests (per MIL-STD 202).

And the **three-year guarantee SRA-1** is still **only $7.95!** Of course, the additional testing adds to our cost, but our continuing commitment is to offer performance and reliability unmatched for off-the-shelf double-balanced mixers.

So, for space or rugged industrial applications, ensure highest system reliabilty by specifying **SRA-1** mixers, the only double-balanced mixers with a **three-year guarantee** . . . from Mini-Circuits where low price goes hand in hand with unmatched quality.

Model
SRA-1

Freq. range (MHz)			
LO	0.5-500		
RF	0.5-500		
IF	DC-500		
Conversion loss (dB)		**Typ.**	**Max.**
1-250 MHz		5.5	7.0
0.5-500 MHz		6.5	8.5
Isolation (dB)		**Typ.**	**Max.**
0.5-5 MHz	**LO-RF**	50	45
	LO-IF	45	35
5-250 MHz	**LO-RF**	45	30
	LO-IF	40	25
250-500 MHz	**LO-RF**	35	25
	LO-IF	30	20

Min. Electronic Attenuation (20 mA) 3 dB Typ.
Signal, 1 dB Compression Level +1 dBm
Impedance All Ports, 50 Ohms
LO Power +7 dBm

Mini-Circuits

2625 East 14th Street Brooklyn, New York 11235 (212) 769-0200
Domestic and International Telex 125460 International Telex 620156

B35/Rev/A

CIRCLE NUMBER 127

New, Simplified Modular Pot...

Conductive Plastic performance at a Molded Carbon price.

We've combined the superior performance of conductive plastic elements with a simplified three-piece design to give you the many advantages of conductive plastic at molded carbon prices. It's the Bourns Model 91/92 family of 5/8″ modular pots. An all new modular pot on the board — or the panel — for under a dollar*.

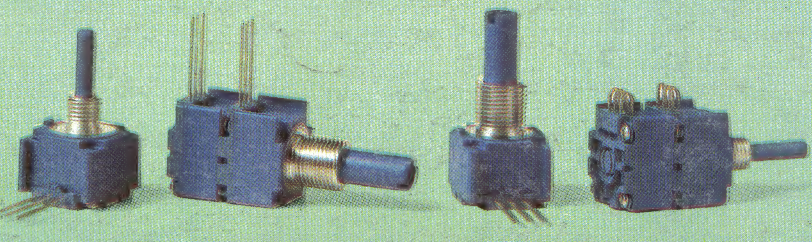
Performance? It's no contest! The conductive plastic element outperforms molded carbon with longer rotational life ($\geqq$100,000 cycle life at 2% max. CRV), tighter linearity (±5%), lower CRV (1% or better), and essentially infinite resolution. And, fewer parts mean added reliability.

Flexibility? You've got it! Terminals are in-line PC style on .100-inch centers. Position them forward, back, or down for vertical or horizontal PC board mounting. Or, mate them with in-line connectors designed for .025 square pins. Solder lugs are formed from PC pins to accept three #22 AWG wires. They're available in two bushing sizes, six tapers and three standard shaft lengths up to 7/8″ long. Resistance values range from 250 ohms to 5 megohms.

Need a high quality, industrial grade modular pot for under a dollar? It's simple! Send today for your new 32-page PC-1 Panel Control catalog and details on the amazing Model 91/92 family.

CONTROLS DIVISION, BOURNS, INC., 1200 Columbia Ave., Riverside, CA 92507. Phone: 714 781-5212. TWX: 910 332-1252.
European Headquarters: Bourns AG, Zugerstrasse 74 6340 Baar, Switzerland. Phone: 042 33 33 33. Telex: 78722.

*Single cup quantities over 5,000. Domestic U.S.A. price only.



BOURNS®

For Immediate Application—Circle 130 For Future Application—Circle 230